Project Title: Consultant Services for an Offsite BMP Evaluation Plan

Final Report to the Wichita Stormwater Advisory Board
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Report Prepared by Kansas State (Trisha Moore, Ron Graber, Kelsey McDonough, and Jacob Zortman) and Vireo (Scott Schulte and Patti Banks)

Executive Summary

The purpose of this report is to document an implementation framework to establish an offsite BMP program. The goal of an offsite BMP program is to (1) maximize the economic efficiency by which the City of Wichita meets its National Pollutant Discharge Elimination System (NPDES) stormwater permitting requirements while (2) improving water quality in the Little Ark, Arkansas, and/or other priority streams for which total maximum daily loads (TMDLs) have been established. Sediment is the primary pollutant of concern in these watersheds, and therefore serves as the basis for the recommended structure and funding of an offsite program. Additional criteria posed by the City for this program include (1) *the program is self-sustaining and does not impose a cost-burden to the City and (2) the program satisfies all regulatory expectations and does not incur additional regulatory or financial liability*. The organization of this report follows the four primary tasks identified by the project team needed to provide the City with the desired program framework. Major findings associated with each of these tasks are highlighted in the following summary.

Task 1: Identify alternative City practices with potential to serve as offsite stormwater BMPs. The project team met with the City's stormwater program managers to discuss current stormwater management and to identify practices or programs that could be expanded to an offsite BMP program. While the City manages multiple programs to improve stormwater quality (e.g., street cleaning, storm sewer and regional outfall cleanout, and streambank stabilization projects) these programs are largely covered under the City's existing Municipal Separate Storm Sewer System (MS4) permit, and thus, are not likely to be recognized as alternative offsite practices from a regulatory standpoint.

Task 2: Evaluate cost effectiveness of internal versus external managed program. Whole life cycle costs of onsite and offsite water quality BMPs were evaluated to demonstrate the cost effectiveness of offsite (i.e., rural/agricultural) versus onsite (i.e., urban) BMPs from a sediment removal standpoint. The results of this analysis indicated that BMPs implemented in a rural setting are *extremely likely* to be more cost effective (we estimate by 2 to 3 orders of magnitude) for sediment removal than BMPs implemented within the City of Wichita. To capitalize on this cost benefit, the project team recommends an externally managed program by WRAPS (Watershed Restoration and Protection Strategy) or a similar watershed-based entity. The Little Arkansas WRAPS program is specifically recommended in order to leverage the social capital developed between the Little Ark WRAPS and rural landowners in the watershed as well as the program's existing infrastructure to prioritize, incentivize, and distribute payments for BMP implementation.

Task 3: Develop framework and tools for implementation of an offsite BMP program. Following the results of the economic analysis under Task 2, a framework for an offsite BMP program in which the City partners with WRAPS to administer the program is presented. Key program elements for which WRAPS would be responsible include: identifying and prioritizing BMP implantation sites, engaging potential offsite program participants, distributing payments to offsite program participants, tracking sediment credits supplied by offsite BMPs and replacing BMPs as needed to ensure continued supply of sediment credits. Other key programmatic elements of an offsite program for which recommendations were developed include (1) setting a common program "currency" (tons of sediment); (2) setting an offsite-to-onsite sediment credit ratio that is favorable from a regulatory standpoint of 2:1; (3) adopting a transparent method by which to set payment rates for participation in the offsite program based upon whole life-cycle *program* costs for implementation of what is expected to be the most typical offsite BMP(s) implemented under the program (conversion to no-till); and (4) adopting an administrative structure that utilizes existing frameworks within the City to permit stormwater projects associated with new/redevelopment and within WRAPS for tracking offsite BMP implementation, maintenance, and expenditures. Based on discussion with members of the SWAB, a 10-year reserve of sediment credits is recommended to assure a sufficient supply of readily available sediment credits and to avoid interruption in development activities. To adequately front-load the program, a sediment credit "bank" would be established in Year 0 of the program with funds sufficient to finance a 10-year supply of sediment credits by Year 1 of the program. These funds would be transferred to WRAPS (or similar external entity), which would then be responsible for spending these funds on targeted water quality BMP projects as needed to accumulate the required 10-year supply of sediment credits prior to making the option for offsite BMP implementation available to new and redevelopments in Year 1. **To ensure that the program is financially sustainable, an annual fee structure is preferred. A spreadsheet tool has been developed and provided to the City of Wichita to determine appropriate annual fees for a specified set of program assumptions. The project team recommends that the City evaluate the fee structure on a regular basis and adjust as necessary.**

<u>*Task 4: Develop program funding options*</u>. As indicated in under Task 3, a source (or sources) of funding are needed both for the initial start-up of the program as well as ongoing funding to the program. A suite of potential funding mechanisms by which the life cycle costs associated with an offsite BMP implementation program could be financed are presented for consideration. These include funding mechanisms that specifically target developers (via a capital charge or impact fee), owners of the properties for which runoff quality is mitigated offsite (via a system development charge or special assessment fee), and/or all Wichita citizens (via the City's stormwater utility fee, property taxes, or a dedicated local sales tax). Based on precedent set by other offsite water quality programs and assessment of the primary benefactors of the program, the most feasible of these mechanisms include the capital charge and system development charges or impact fees to the developer and/or property owner.

Project objectives

The overall goal of this project is to document an implementation framework to establish an offsite BMP program by which to (1) maximize the economic efficiency by which the City of Wichita meets its NPDES stormwater permitting requirements while (2) improving water quality in the Little Ark and Arkansas Rivers. Since sediment is the primary pollutant of concern in the TMDL watersheds listed in the City's MS4 permit (KDHE, 2014), the program will be based on sediment removal. In addition to these criteria, the City of Wichita requires that the program is constructed and operated such that (1) it is permanent in nature and, related to this, (2) will not leave the City with future liabilities. The framework presented attempts to address each of these requirements by accounting for the true cost of offsite BMPs – including perpetual operations, maintenance and eventual replacement costs – in the life cycle analysis using best available estimates of future inflation to develop a funding framework that will ensure the financial permanence of the program. The program structure has been developed in concert with guidance from the Kansas Department of Environment and Health (KDHE) to address concerns of future liabilities and ensure that the program is indeed contributing to the greater watershed water quality goals. The following tasks were proposed to develop an offsite BMP program that is both environmentally and financially feasible:

- *Task 1: Identify alternative City practices with potential to serve as offsite stormwater BMPs.* The goal of this task is to inventory practices and programs within the City with the potential to impact stormwater quality and identify those that could be considered as offsite BMPs.

- *Task 2: Evaluate cost effectiveness of internal versus external managed program.* Under this task, costs associated with a program managed either internally by the City or externally by another entity will be quantified and compared. Sediment has been identified as the primary pollutant of interest; therefore, life cycle costs of various water quality BMPs will be normalized against potential sediment removal benefits.

- *Task 3: Develop framework and tools for implementation of an offsite BMP program*. An implementation framework will be developed for an offsite program administered either by the City or an external entity (i.e., WRAPS), depending upon which of these program management options is determined to be most economically effective through Task 2.

- *Task 4: Develop program funding options*. Results from life cycle cost analysis to be completed under Task 2 (and will include "cradle-to-grave" capital costs, expected maintenance, and replacement costs) will be used to establish funding requirements for offsite BMP projects. Drawing on expertise from project partners including Vireo, a suite of potential funding mechanisms by which these costs could be covered will be developed and presented to the City.

The following report is organized according to each of these proposed tasks, in which results and recommendations associated with each task are presented.

Task 1: Identify alternative City practices with potential to serve as offsite stormwater BMPs.

Toward completing this task, members of the project team consulted with City of Wichita stormwater staff for a briefing of the City's stormwater program and to identify pertinent documents for review. The purpose of this review was to identify practices and programs within the City with the potential to impact stormwater quality and identify those that could be considered as offsite BMPs. Key document reviewed included the City's Municipal Separated Storm Sewer System (MS4) permit, approved in July 2014 by the Kansas Department of Health and Environment (KDHE) and the City's Stormwater Management Plan, updated and approved as part of the MS4 permit requirements. This permit outlines practices and programs currently practiced by the City to meet stormwater discharge quality obligations. The City's stormwater programs and practices, their implementation status with respect to the NPDES MS4 permit, and potential for expansion as an offsite program are summarized in Table 1.

Table 1. Summary of City of Wichita stormwater programs and practices and potential for expansion in offsite program.

Stormwater control measure	Description	Potential to serve as offsite program
Streambank stabilization projects	The City has stabilized numerous degrading stream reaches, most notably Gypsum Creek and Edgemore Park. "No mow" buffer ordinances have also been implemented to reduce streambank erosion	**Low**: while stream stabilization and/or restoration projects may reduce sediment loadings substantially, such efforts are counted under Section 1.E. (concerning control of TMDL Regulated Pollutants) in the MS4 permit.
Storm sewer pipe and catchbasin cleanout	As part of regular maintenance, the City removes sediment from the storm sewer system. A high powered "water saw" was recently purchased to facilitate pipe and culvert cleanout.	**Low**: permit requires *at least* 30,000 catchbasin cleanouts per year as part of six minimum control measures. Sediment removal via this program is documented and reported to KDHE.
Meridian Outfall	Recently constructed, this 8' x 10' outfall drains approx. 600 acres. Construction cost was $600k-700k; frequency of cleaning to be determined. Life cycle costs and potential sediment removal estimates can be refined as the City gains operating experience.	**Low-Medium**: "Regional" outfalls such as this could be considered out side of required catchbasin cleaning; however, may be considered under section 1.E. of MS4 permit.
Street Sweeping	Also part of regular "housekeeping", the City conducts street sweeping over 25,283 land miles to remove over 10,000 tons of sediment annually.	**Low**: Street sweeping is also identified as a required best practice under the City's current MS4 permit.

The goal of this task was to explore the possibility of building upon established stormwater programs that could be used in lieu of implementing BMPs at the site of new and redevelopment as required under section C.1. of the MS4 permit. Such a program could be considered a low hanging fruit; however, as indicated by the status of each program reviewed in Table 1, these programs are considered to fall within the purview of the City's MS4 permit; that is, the City is expected to continue implementing these programs and would not receive additional credit for expanding these efforts (e.g., cleaning more than 30,000 catch basins per year). Therefore, based on discussions with the City of Wichita's stormwater staff and review of pertinent documents, it is unlikely that any of the City's existing water quality efforts could be expanded to as an offsite program under the language of the current MS4 NPDES permit.

Task 2: Evaluate cost effectiveness of internal versus external managed program.

The primary objective of this task was to quantify costs associated with a program managed either internally by the City or externally by another entity. Established Watershed Restoration and Protection Strategy (WRAPS) programs were the primary entities considered for the external management option, with a specific focus on the Little Arkansas and River City WRAPS programs within which the City of Wichita lies. Rational for focusing on existing WRAPS programs for the management of the offsite BMP option included: (1) agricultural landscapes are a large source of the sediment and other pollutants contributing to the Little Ark, Cowskin Creek and Arkansas River TMDLs listed in the City's MS4 permit, (2) there exists large potential for more cost-effective BMP implementation relative to urban areas of the watershed (Roe et al., 2013), (3) WRAPS has an established process for working with landowners to implement and finance water quality BMPs and (4) analogous efforts to reduce atrazine transport from the rural landscape to the City of Wichita through WRAPS-facilitated implementation of agricultural BMPs have proven successful (Devlin et al., 2011).

Two sub-objectives were associated with this task (Figure 1). First, a cost-benefit analysis comparing onsite (representing a City-managed program with implementation of urban BMPs) and offsite (representing an externally managed WRAPS program and implementation of rural BMPs) BMPs was conducted. The cost-benefit analysis for both onsite and offsite BMPs considered the cost to construct, maintain, and replace BMPs. The specific types of BMPs for which life-cycle analyses were conducted are listed in Table 2. Second, estimates of sediment removal by each BMP type were obtained from the literature. Whenever possible, monitoring and or modeling data specific to Wichita and/or South Central Kansas was used. For each BMP type, annualized costs per ton sediment removed were calculated. Methods for calculating life cycle costs and annual sediment removal potential for each BMP type are summarized in the following sections. A more detailed account of relevant assumptions and line-item costs is provided in Appendices A and B for onsite and offsite BMPs, respectively.

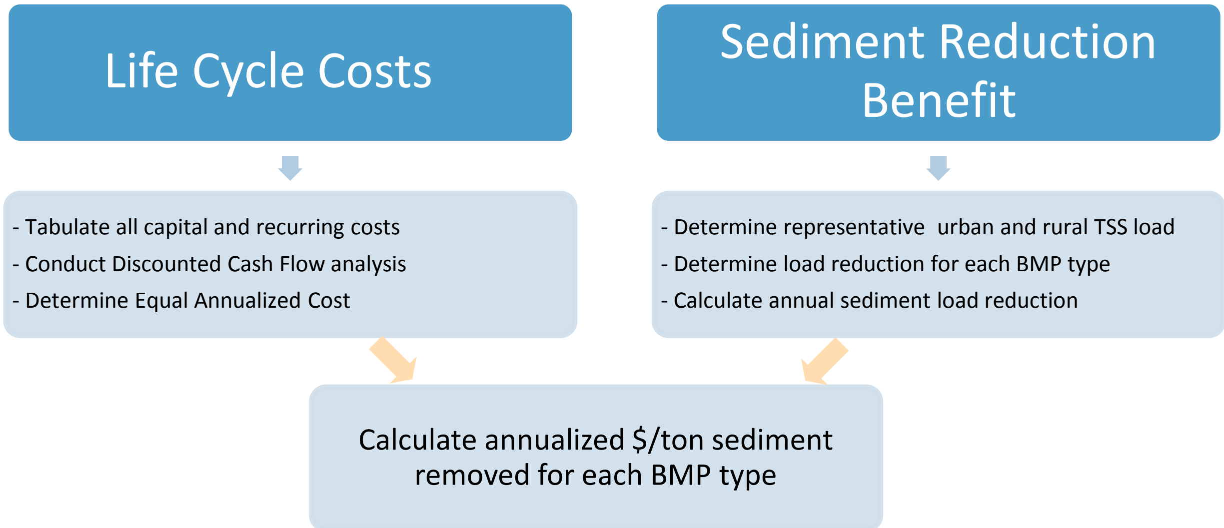

Figure 1. General method applied to calculate life cycle cost-benefits of onsite (urban) and offsite (rural) BMPs

Table 2. Onsite and offsite BMPs to be considered for cost-benefit analysis.

Onsite BMPs	***Offsite BMPs***
Bioretention/raingarden	Streambank stabilization
Extended detention basins	Wetland restoration
Water quality swale	Permanent vegetation
Pervious pavement	Terrace-waterway system
Hydrodynamic separator	No-till cropping practice
Grass filter strips	Grass filter strips
Riparian setbacks	Riparian buffers

2.1 Life cycle costing models

2.1.1 Life cycle cost estimates associated with onsite BMPs (assumed to be located in urban areas) and offsite BMPs (assumed to be located in rural areas) were tabulated and compared on the basis of the net present value (NPV) of each BMP type over the BMPs life span (assumed equal 25 years). In essence, the NPV provides an estimate of the amount of money that would need to be spent in the present time to cover all expected future costs as they arise through the operation of a BMP. The NPV is a function of the capital expenditures, maintenance costs, administrative/overhead, discount rate, and design life. A description of each of these components and their application to the onsite versus offsite BMP cost analysis is provided in Table 3.

Table 3. Net Present Value components.

NPV component	Description
Capital Expenditures	Includes all one-time costs, such as engineering design and project management, permitting and construction inspection, and the cost of construction materials, equipment operation, and labor. Land opportunity costs are also considered.
Maintenance costs	Includes on-going costs associated with operations and maintenance of BMP facilities, and include the costs of materials and labor. Maintenance costs are assumed to be incurred on an annual basis.
Program administrative costs	Includes additional costs to administer an offsite program managed either internally by the City or externally by another entity. These costs would cover additional need for tracking, verifying and reporting BMP implementation. In either case, administrative costs are assumed equal to 30% of the total BMP implementation cost.
Discount rate	Interest rate used in discounted cash flow analysis to determine present value of future cash flows. Rate considers time value of money as well as uncertainty in future cash flows (greater uncertainty reflected by higher discount rate). A 5% discount rate was assumed for onsite BMPs (NCHRP, 2014), in line with the interest rate charged by the federal reserve on loans to institutions borrowing money from it, and assumed to be passed on to private developers. Per the standard practice in agricultural economics, the federal discount rate for water quality projects of 3.75% (USDA-NRCS, 2013) was assumed for offsite BMPs.
Design life	A 25-year period was assumed following the typical design life span assumed for stormwater BMPs.

Life cycle cost estimates for urban BMPs were developed based on construction, maintenance, and administrative costs compiled by the National Cooperative Highway Research Program (NCHRP, 2014), and are detailed in Appendix A. Similarly, cost estimates for the construction and maintenance of offsite BMPs were assembled based on documented costs of various water quality BMPs implemented in northeast and southcentral Kansas (Smith et al., 2011; Devlin et al., 2003; Roe et al., 2013). Details regarding cost assumptions for offsite BMPs are documented in Appendix B. For consistency among BMP comparisons, capital and recurring costs were calculated based on BMP design specifications as required to treat a 1-acre watershed, assumed 100% impervious for onsite (urban) BMPs and 100% cropland for offsite (rural) BMPs. Design specifications for onsite BMPs were taken from the APWA-MARC BMP design manual (2012) while NRCS design specifications were referenced for offsite water quality BMPs.

As noted in Table 3, land opportunity costs were taken into consideration to account for revenue forgone by dedicating land to water quality BMPs. This foregone opportunity may be manifested as a loss of development profit in urban areas, or to loss of rental or production revenue in rural areas. Though they vary widely across time and space, land opportunity costs are an important consideration as they may substantially increase life cycle costs of water quality BMPs implemented in both urban (e.g., Wossink and Hunt, 2003) and rural (e.g., Smith, 2011) settings. Opportunity costs were estimated separately for onsite (assumed to be located in urban areas) and offsite (assumed to be located in rural areas) based on their respective land values. Urban land values were separated into both commercial and residential land uses. The opportunity costs associated with these land uses was estimated as $30,000 and $95,000 per acre, respectively (J. Hickle, personal communication). The opportunity cost associated with allocating rural lands for water quality BMPs is typically equated with land rental rates. As a proxy, county-level rental rates for non-irrigated cropland were obtained from the Kansas State Economics Department (Taylor and Dhuyvetter, 2014) for counties within the Little Arkansas River watershed: McPherson ($91.80 per acre), Harvey ($90.50 per acre), and Sedgewick ($76.10 per acre).

2.1.2 Sediment reduction benefits associated with each of the BMPs listed in Table 2 were estimated using available literature estimates for the Little Arkansas River physiographic region. Influent sediment concentrations delivered to onsite (urban) BMPs were assumed equal to the sediment concentration typical of roadways and parking lots (140 mg/L) as based on an extensive review of stormwater quality data contained within the International Stormwater BMP Database conducted by NCHRP (2014). This concentration is believed to be appropriate for conditions in Wichita based on additional analysis of the City's wet weather sampling data, the average concentration of which was 149 mg/L across 12 sampling stations. A water quality BMP performance tool developed by the NCHRP was used to predict the average sediment load associated with a median runoff concentration of 140 mg/L based on historical precipitation data recorded at the Wichita Mid-Continent Airport. The average annual precipitation depth at this station was 30.2 inches. Assuming a runoff coefficient of 0.9 from an impervious watershed, an annual sediment load of 850 lbs sediment per acre per year was calculated (equivalent to 0.4 tons/acre/year). For offsite BMPs, an annual sediment load from cropland in the region was estimated as 4.5 tons per acre per year based on monitoring and modeling data (Mankin et al., 2007; Douglas-Mankin et al., 2013). Sediment removal potential by each BMP was estimated using the BMP water quality performance tool developed by NCHRP for Wichita precipitation data for onsite BMPs and through literature values (documented in Appendix B) for offsite BMPs.

2.2 Results: Cost effectiveness of sediment removal for onsite and offsite BMPs

Life cycle costs associated with each BMP were annualized based on the assumptions stated in the previous section. These costs were then normalized according to annual sediment reduction potential of the BMP. Resulting cost effectiveness per ton sediment removed for onsite and offsite BMPs are summarized in Table 4. As indicated by the results of the life-cycle cost benefit analysis, runoff sediment reductions are likely to be significantly more cost effective via BMPs implemented in offsite, rural areas than via BMPs implemented onsite in new and re- urban developments. There are multiple reasons for this cost differential, but perhaps the most outstanding is the stark difference in sediment loads delivered from urban (median runoff concentration assumed equal to 130 mg/l) versus rural (median runoff concentration assumed equal to 4,500 mg/l) landscapes. Land opportunity costs are also likely to be higher in urban settings. Costs associated with project management and engineering design also tended to be higher for onsite BMPs.

Table 4. Comparison of annualized life cycle costs associated with onsite and offsite BMPs, expressed per ton sediment removed per acre watershed area.

$ / ton sediment removed / (impervious) acre treated / year		
Onsite BMPs	Residential	Commercial
Bioretention/raingarden	$7,240	$9,160
Extended detention basin	$18,080	$18,600
Water quality swale	$8,660	$9,060
Pervious pavement	$22,800	$22,800
Hydrodynamic separator	$16,060	$16,060
Grass filter strips	$3,020	$9,060
Riparian setbacks	$4,800	$10,760
Offsite BMPs	Rural (Cropland)	
Grass filter strips	$4.83	
Streambank stabilization	$2.58	
Permanent vegetation	$35.29	
Wetland restoration	$11.93	
Terrace-waterway system	$8.97	
Riparian buffers (forested)	$14.61	
No-till cropping practice	$8.99	

It should be noted that the costs associated with urban BMPs are likely conservative (high) since all design and construction activities were calculated as though the BMPs were stand-alone features rather than part of a larger development. In actuality some activities would be performed and costs incurred by the development regardless of BBMP requirements, including mobilization, clearing and grubbing, mass grading and excavation, and basic landscape establishment. Other costs such as fine grading would be required for the BMPs and are not included in the estimate. In addition, estimating the costs of single, stand-alone urban BMPs discounts the capital and operations and maintenance economies of scale that may be realized on larger development projects where multiple BMPs would be constructed and maintained. However, many smaller commercial, industrial or even residential projects could conceivably require small, stand-alone BMPs, so the standard of comparison is valid, although again somewhat conservative. The City is currently conducting a survey of developers who have been required to implement onsite water quality BMPs as part of the City's MS4 program. Among the objectives of this survey is to quantify the costs of onsite stormwater quality treatment incurred by developers. When completed, the results of this survey could be used to better quantify the net buy-up associated with installing water quality BMPs onsite versus developing the land for other uses.

2.3 Application of unit life cycle costs to assess program feasibility

Life cycle costs presented in Table 2 represent the unit sediment removal cost per impervious acre runoff treated. While convenient for comparing sediment removal costs in common terms, further consideration of the scale at which these BMPs are typically implemented is necessary to gain greater insight to the feasibility of an offsite BMP program. For instance, minimum acceptable project sizes may determine the feasibility to implement offsite BMPs such as streambank stabilization or conversion to no-till. Conversely, on-site development may meet water quality requirements with relatively little additional cost, particularly in the case of large developments for which stormwater peak rate control is required. Equally important to assessing program feasibility is a consideration of the demand and supply of credits for sediment load reductions. Issues of scale and supply-demand are addressed in the following sections.

2.3.1 Demand for sediment credits. To assess the potential demand for offsite water quality BMPs, it is useful to frame the analysis in terms of an annual sediment budget. On average, the City of Wichita expects to develop or redevelop 600 acres per year, half of which can be assumed to be dedicated to commercial land uses while the other half for residential.[1] Assuming a typical event mean sediment concentration of 140 mg/l, which is equivalent to about 0.6 tons per million gallons (MG), annual sediment load associated with projected new and redevelopment can be estimated as 190 tons (Table 6). Assuming a credit ratio between 2 and 3 were adopted, new and redevelopment in Wichita would create demand for up to 380 to 570 tons of sediment removal in the watershed per year.

Table 5. Estimated sediment load, as estimated by total suspended sediment (TSS) concentrations in runoff, generated by new and re-development projects within the City of Wichita.

Land use	**Impervious area** (%)	**Annual runoff** (MG/ac/yr)[a]	**Median TSS conc.** (tons/MG)	**Total sediment load** (tons/ac/yr)
Commercial	85	0.72	0.6[b]	0.43
Residential	35	0.37	0.6[b]	0.22
Average onsite sediment generation……………………..………..…**0.32 tons/ac/yr**				

[a]Calculated assuming a runoff coefficient of C = 0.88 for commercial land uses and C = 45 for residential land uses, corresponding to assumed impervious surface cover and Type B soils.
[b]Median sediment concentration estimated from NCHRP (2014) and City of Wichita stormwater monitoring program data.

The calculations presented in Table 5 assume that all new and re-development projects would be interested in participating in the offsite BMP implementation program. However, this may not be the case, particularly for large developments in which the incremental costs to meet water quality requirements is not that much greater than the cost to provide required hydraulic control – requisite even if the development participates in the offsite program. In Wichita, the most common method of meeting both stormwater detention and quality requirements onsite is through wet detention basins, particularly for

[1] Projected development rate of 600 acres per year recommended by Wichita Stormwater Advisory Board members, Jan. 9th, 2015.

larger residential developments. Incremental costs associated with meeting hydraulic and water quality requirements are presented in the following section and detailed are within Appendix A.

2.3.2 Supply of offsite sediment credits. Along with the supply of sediment credits that could be provided by offsite BMPs, it is also important to consider the scale at which offsite BMPs are typically implemented. Such a consideration is needed to better understand which BMPs are most feasible given the expected demand for sediment credits generated by new and re-development in the City of Wichita and the cost to supply required sediment credits for BMPs implemented at realistic scales. Typical implementation areas for a single offsite BMP installation are presented in Table 6, along with the net present value (NPV) of all present and future costs and annual sediment reductions supplied by the BMP throughout its lifetime. The ratio of sediment reduction credits supplied by each offsite BMP to the expected demand from the City (584 tons/year assuming a 2:1 credit ratio) is presented in the final column of the table. For those BMP types with ratios less than 1 (e.g., riparian buffers), either multiple projects of this BMP type would likely be required each year and/or this BMP would be part of a suite of other water quality BMPs with ratios greater than 1. If BMPs with ratios greater than 1 are the primary type of BMP implemented as part of an offsite program, then offsite projects may not necessarily be implemented every year but, rather, on a schedule as needed to maintain an acceptable balance of sediment reduction credits to supply future demand from new and re-development. Examples of the cash flows needed to balance sediment supply and demand for no-till and streambank stabilization are provided in Table 9 under Task 3 as well as Tables D.1-D.3 in Appendix D.

Table 6. Net present value of life-cycle (25-yr) costs for potential offsite BMPs. If incorporated in an offsite BMP implementation program, the NPV provides an estimate of the required payment up front to cover both present capital and future recurring costs. The typical scale of BMPs implemented in the Little Ark was determined from experience in the Little Ark WRAPS program (Schlender and Graber, personal communication). Line-item capital and maintenance costs associated with each BMP type are documented in Appendix B.

BMP type	NPV ($/ac treated)	Sediment capture (t/ac/yr)	Typical scale (ac)	Total cost	Total sed. removed (t/yr)	Ratio: onsite sed to offsite removal[a]
No-till cropping practice	$635	3.2	430	$273,050	1,376	3.6
Grass filter strips (contour)	$2,547	32	35	$89,145	1,120	3.2
Terrace-waterway system	$2,660	18	400	$1,064,000	7,200	18.8
Permanent vegetation[b]	$2,443	4.2	100	$244,300	420	1
Riparian buffers (forested)	$2649	11	10	$26,490	110	.28
Streambank stabilization	$56,119	590	3	$168,357	1,770	4.6

[a]Assumes 384 tons sediment is generated from onsite new and re-development in Wichita per year. See Table 5 for calculation.

[b]Note that "permanent vegetation" is assumed implemented on a contract basis (the most favorable among landowners in the surrounding area) rather than a permanent easement.
[c]costs estimated from experience with Lenexa's Rain to Recreation program.

2.4 Potential for additional environmental benefits

While sediment is the primary water quality concern in TMDL watersheds within and surrounding the City of Wichita and will serve as the basis for fees to participate in the offsite BMP program, the offsite BMPs considered in Table 6 are likely to provide environmental benefits in addition to sediment retention (Table 7). Some of these additional benefits, particularly hydrologic regulation, may even be synergistic with sediment reduction. For instance, practices that enhance infiltration or otherwise attenuate hydrologic discharges entering streams can also contribute to reduced streambank erosion (Tomer et al, 2011). Land management practices such as no-till adoption, cover crops, and vegetative filter strips and buffers are known to enhance nutrient retention and cycling, carbon sequestration, and provide wildlife habitat. Approaches such as streambank stabilization are likely to reduce sediment and associated phosphorus, but is less likely to provide a greater suite of environmental benefits.

Table 7. Environmental benefits associated with offsite BMPs. Green plus sign indicates benefit is enhanced by the BMP, red O indicates the benefit is likely neutral.

Environmental Benefit	No-till	Cover crop/ rotation	Terrace-waterway	Grass filter strips	Permanent vegetation	Riparian buffer	Stream bank stabilization
Sediment retention	+	+	+	+	+	+	+
Nutrient retention	+	+	+	+	+	+	+/O
Soil health	+	+	O	+	+	+	O
Carbon sequestration	+	+	O	+	+	+	O
Habitat provision	O	O	O	+	+	+	O
Hydrologic regulation	+	+	+	+	+	+	O

From a regulatory standpoint, offsite BMPs that contribute to the broader ecosystem health of the watershed are preferred over those that address sediment only. **KDHE has specifically expressed its favor for land management BMPs such as no-till farming, cover crops and crop rotation.** As indicated in Tables 4 and 7, these BMPs are expected to give the most "bang for the buck." Inclusion of non-structural or otherwise non-permanent BMPs such as no-till can still be compatible with the City's criteria of "perpetual" offsite water quality assurance by structuring program fees to cover replacement costs for non-structural BMPs. Doing so can ensure a constant supply of offsite credits that exceed sediment generation from onsite properties while maintaining a financially sustainable program. Approaches for ensuring the permanence of sediment credits generated by non-permanent offsite BMPs are discussed in Section 3.2.5.

2.5 Summary of onsite versus offsite BMP cost analysis & program framework implications

Under Task 2, life cycle costs associated with offsite and onsite BMPs were compared. Major conclusions from this analysis include:

1. Offsite BMPs implemented in a rural setting are highly likely to be more cost effective for sediment removal than BMPs implemented within the City of Wichita, by 2 to 3 orders of magnitude as estimated here. Thus, we recommend an offsite program implemented through cooperation with an established, local entity to gain access to offsite BMP implementation sites outside of the City and optimize program costs. Although administrative costs were assumed equal for the BMP life cycle analysis above, in reality, partnering with an established entity such as WRAPS that has existing mechanisms by which to identify, prioritize, and implement BMPs will minimize administrative start-up costs.

2. Given the potential supply of sediment credits provided by offsite BMPs (Table 6) relative to demand (Table 5), it is highly unlikely that the demand for sediment credits generated by an offsite BMP implementation program would outpace the supply. Thus, from a supply-demand standpoint, such a program is feasible.

Life-cycle costs of the individual offsite BMPs examined here will be used to project the costs associated with an offsite program. Program costs will ultimately be used to set a payment rate associated with a single sediment credit, and must account for the life-cycle costs of offsite BMPs implemented throughout the duration of the program. Other programmatic aspects, such as an offsite sediment credit ratio, must also be considered when developing program cost estimates. It is these programmatic aspects that are the focus of Task 3.

Task 3. Develop framework and tools for implementation of an offsite BMP program

The goal of Task 3 is to deliver an implementation framework for an offsite program. Given that an externally managed program was found to be the most economically (and environmentally) efficient (Task 2), the implementation framework presented herein assumes the program is administered by WRAPS or a comparable external entity. As an introduction, this report on Task 3 begins with a review of programs in which water quality needs of a City have been met offsite through partnership with rural landholders. The purpose of this review is to extract relevant guidance and lessons learned from existing programs. Next, specific program elements for an offsite BMP implementation program that meet the requirements of the City's existing stormwater manual and MS4 permit are outlined along with the tools needed to implement the program. Finally, suggested responsibilities and expectations of all parties involved in the offsite BMP program are outlined. **Each of these activities is intended to support the development of a program framework that satisfies the City of Wichita's top priorities for the program, namely:**

1. *The program is self-sustaining and does not impose a cost-burden to the City and*
2. *The program satisfies all regulatory expectations and does not incur additional regulatory or financial liability*

3.1 Review of existing offsite water quality programs

The program proposed by the City of Wichita is unique and, to the knowledge of the project team, has not been implemented or publicly documented elsewhere. However, there are existing offsite water quality programs of which particular elements are relevant to Wichita. These have been reviewed by the project team and are summarized in Table 8. Multiple MS4s throughout the US have developed and/or considered offsite BMPs as an alternative means of meeting post-construction stormwater water quality regulations (CWP, 2012). The majority of these programs have been developed such that the offsite practice is implemented within the city limits (such as Lenexa's "Rain to Recreation" program), either (1) by the City on public property or on private property secured through easements or (2) through a mitigation banking system in which an offsite party implements a BMP on their property, credits for which are certified by the bank and then made available for purchase by onsite parties interested in purchasing credits in-lieu of implementing their own BMPs onsite. The payment rate associated with these programs ranged from $14,300 (Lenexa's "Rain to Recreation" program) to $90,000 (Charlotte, NC) per impervious acre developed (Appendix D). The exception was a program implemented within the Neuse River watershed in North Carolina in which the offsite program was structured to support implementation of offsite agricultural BMPs (as opposed to offsite urban BMPs) for new and redevelopment projects that are unable to meet onsite stormwater nutrient reduction requirements. Payment rates for developer participation in this program range from approximately $250 to $450 per impervious acre (CWP, 2012). This review of administrative structures for existing offsite market-based programs further reinforces the idea that economic efficiency can be increased by meeting water quality requirements through offsite BMPs in rural areas.

Table 8. Summary programs in which municipalities have utilized offsite BMP programs to meet water quality targets in which offsite BMPs are implemented in rural areas.

Municipality	Need for offsite program	Provider of offsite treatment	Indicators of success	Funding Sources	$/impervious acre for offsite pollutant
Cities within North Carolina	Nutrient pollution in critical watersheds	NC Ecosystem Enhancement Program, via riparian buffers	Significant riparian buffer restoration, ahead of development	Developer (in-lieu fee)	Nitrogen: $252-$462 Phosphorus: $362
Cities within Chesapeake Bay, Virginia	Excess phosphorus pollution	Farmers/developers through a credit trading program	In Progress	Developer (in-lieu fee)	Runoff Volume: $87,750
Lenexa, KS "Rain to Recreation"	To provide stormwater quantity and quality control more economically	City of Lenexa, via utilization of public land and private land acquisition	Community support, cost savings to city, numerous national awards	Developer (Capital charge), 1/8% sales tax, stormwater utility	Runoff volume: $14,300
Cheney Lake Watershed, Kansas	Taste & odor problems in drinking water from blue-green algae blooms/high phosphorus	Agricultural landowners/ operators in Cheney Lake Watershed implement BMPs	Stabilization in number and frequency of algae blooms in Cheney Lake	City of Wichita, KDHE, NRCS, government funds secured by non-profit CWLI	Not given
New York City, NY	Decline in drinking water quality	Farmers in the Catskill/Delaware Watershed implement BMPs, purchase of land for conservation by the city	EPA granted a filtration avoidance determination in 2007 to the city	New York City	$1.4 billion (compared to $6 billion for a facility + $250 million in annual operating costs)
Munich, Germany	250% increase in nitrogen concentration in water from 1974 to 1992	Farmers in surrounding watersheds switch to organic farming	Nitrogen levels return to levels seen in 1974, over 80% of farmers under contract	City of Munich	Increase cost of water by 0.005€/m^3 (instead of 0.23€/m^3 for a treatment facility)
Pierce County, Washington	Nonpoint source pollution degrading shellfish, TMDL violations	Stakeholders in Pierce County	At least 50% of action items in watershed plan have been implemented	State Clean Water revolving funds	Not given

3.2 Program elements

Based on the preceding review, common factors that have served to enable or constrain the success of offsite water quality programs can be identified. In general, collaborative programs between municipalities, developers, and/or private landowners can be successful if stakeholders believe that the partnership benefits outweigh the associated transaction costs (Borisova et al., 2012). Three key characteristics for successful collaborative processes are sustained participation, information sharing, and collective documentation (Biddle & Koontz, 2014). Some of the other most salient features of successful programs are:

- *Flexible.* Allowing some flexibility in the types of offsite BMPs that are allowed under the program can increase participation of offsite sediment credit providers while potentially decreasing transaction costs for onsite program participants (Grolleau and McCann, 2012).
- *Prioritized*. Programs in which BMPs are implemented in a targeted fashion with priority implementation on those sites known to contribute to water quality impairments are the most likely to achieve measureable improvements in water quality, thus *maximizing economic efficiency* (Douglas-Mankin et al., 2013; L. French, personal communication).
- *Transparent*. The procedure for setting sediment credit ratios and payment rates should be clear and made available to onsite program participants. A means for representing offsite landowners in the program framework has also provides a measure of transparency, and has proven successful for recruiting offsite participants to the program (L. French, personal communication).
- *Maintain minimum site control measures*. Minimum stormwater control requirements should be in place to avoid making local onsite water quality conditions worse unintentionally.
- *Economically attractive*. In the words of Becerra (2010): Ownership, responsibility, stewardship, and environmentalism have all been found to be motivators for participation in water quality programs. However, these all place second to financial considerations. Therefore, to achieve the sustained participation needed to ensure program success, an offsite program must provide an economic incentive to involved parties. Such incentive can come through economies of scale achieved through larger watershed projects (e.g., as through Lenexa's Rain to Recreation program) and/or implementation of more economic offsite practices (such as riparian buffer restoration through North Carolina's Ecosystem Enhancement Program).

Each of these aspects is addressed within the Program Elements outlined in Table 9 and described with greater detail in the following section. Examples of approaches taken by other cities with offsite stormwater options regarding each of these program elements are summarized in Appendix D.

Table 9. Program elements for offsite BMP implementation program and relationship to existing regulatory frameworks: the City's MS4 General Permit (MS4) and Stormwater Management Program (SMP).

Program Elements	Description and relationship to stormwater permit provisions
Eligibility	Program is open to any party responsible for new- or redevelopment projects in the City of Wichita. Per the MS4 permit and SMP, any such project disturbing one-acre or more has the option of implementing post-construction water quality BMPs onsite or participating in an offsite program to offset water quality impacts.
Minimum site control measures	Per the SMP and MS4 permit, any new or redevelopment must comply with construction site water quality measures for any activity that disturbs more than one acre. Post-construction quantity control must be provided such that peak discharge associated with the 2-, 5-, 10-, 25-, and 100-year return frequency is no greater than predevelopment rates[a]. Additional water quality treatment is not required if the developer opts for offsite implementation.
Currency of offsite mitigation	Sediment, valued in terms of $/ton sediment retained. The focus on sediment is driven by sediment-based TMDLs developed for several stream systems within the City of Wichita (Big Slough, Cowskin, Chisholm, Gypsum, Little Arkansas, and Arkansas) as listed in the City's MS4 permit.
Sediment payment rate	The sediment payment rate is the cost onsite parties would pay to participate in the offsite program in lieu of implementing onsite water quality BMPs. The payment rate should be developed based on the costs of to support a program in which the most typical offsite BMP(s) is (are) implemented. Some flexibility to re-examine this rate and modify as necessary after initial establishment of the program should be allowed.
Offsite sediment credit ratios	Credit ratios are intended act as a factor of safety against uncertainties in BMP removal rates. Typically, onsite participants are required to purchase offsite water quality credits at a rate greater than 1:1. Credit ratios established for offsite programs administered by other MS4s range from 1.5:1 to 2:1.
Spatial bounds	For regulatory purposes, most offsite water qulity programs require offsite BMPs be implemented in the same watershed, though the scale of the watershed (e.g., HUC 12 versus HUC 8) may depend on local water quality goals.
Allowable offsite practices and prioritization	Not limited, but estimated sediment load reductions of any offsite BMP must be documented to ensure development demand is met. Offsite implementation should also follow a *targeted framework*, such as that established by the LAR WRAPS to prioritize top sediment-producing fields.
Program administration	An administrative structure that enables proper tracking and record keeping will be required for an off-site BMP program. Systems for collecting payments for sediment credits, allocating funds to priority offsite BMPs, and tracking and reporting offsite BMP implementation and maintenance are discussed.

[a] City of Wichita Stormwater Policy, Vol. 1 Ch. 3, page 3-9.

3.2.1. Eligibility. By opening participation to new and redevelopment city-wide, economic efficiency and increased program participation is promoted. In addition to new and redevelopment, the City could also consider existing properties to buy into the program. Existing water quality BMPs on these properties would remain in place, but the City would no longer require bi-annual inspection documentation.

3.2.2 Minimum onsite control measures. The offsite BMP implementation program is intended to meet the requirements for post-construction water quality BMPs stipulated in the City's MS4 permit. However, new and redevelopments would still be required to meet peak discharge control and downstream stabilization standards when applicable as outlined in the City's existing Stormwater Policy. Onsite management of gross solids (trash) is also expected for offsite program participants. These minimum onsite control measures are summarized here:

1. **Peak discharge control** is required for any new or redevelopment disturbing over 1 acre. Per this requirement, the calculated peak discharge from each of the site's outfalls for the 2-, 5-, 10-, 25-, and 100-year return interval storm shall not exceed that of predevelopment conditions.

2. **Downstream stabilization** standards apply to any new or redevelopment that will add five or more acres of impervious surface cover and that are located in areas designated by the City and/or county as a Downstream Stabilization Protection Volume Watershed or Stream. This standard requires detention of the 1-year, 24-hour storm volume for at least two days to four days.

3. **Gross solids** (i.e., urban trash) must be managed onsite for all new and redevelopment properties. The City considers snouts as an acceptable trash BMP. Based on conversations with City of Wichita stormwater staff, snouts receiving runoff from new and redevelopments can be positioned along the street such that the City will provide periodic cleaning as part of their regularly scheduled stormdrain cleaning route.

By maintaining these minimum onsite peak flow/detention and trash management practices, new and redevelopment properties buying into the offsite program would *not* be required to meet the existing onsite water quality requirements specified in the City's MS4 permit, namely (1) to construction of onsite water quality BMPs (e.g., bioretention, extended detention ponds/ wetlands, hydrodynamic separators) or (2) to report of maintenance of water quality BMPs. New and redevelopment properties are not required to participate in the offsite program. For these properties, onsite water quality BMPs and biannual maintenance reporting will still be required.

3.2.3 Allowable offsite practices and prioritization. As demonstrated in the preceding discussion of sediment credit payment rates, an offsite BMP implementation program can be created with the intent of allowing permanent BMPs, nonpermanent BMPs, or a mixture of both types. We recommend the latter, as allowing a mixture of both permanent and nonpermanent BMPs will maximize program flexibility and efficiency. Regardless of the types of BMPs the City chooses to allow, we believe the following aspects are essential:

1. The sediment credit payment rate should be established to provide sufficient funds for both the initial implementation *and* expected recurring maintenance costs throughout the foreseeable duration of the program. Preliminary figures for costs based on life cycle program costs for what are anticipated to be the most typical/favorable BMPs in rural watersheds surrounding Wichita (no-till and streambank stabilization) were presented in Table 4 and are discussed in further detail in Section 3.3.

2. Offsite BMPs should follow a defined prioritization scheme to maximize the environmental effectiveness of the program (L. French, personal communication; CWP, 2012). Following the recommendation that WRAPS or similar entity be utilized for identifying and facilitating BMP implementation, the responsibility for BMP prioritization would be the responsibility of the WRAPS group. Such a requirement falls in direct alignment with existing WRAPS activities; for instance, the Little Ark WRAPS program has identified priority areas for sediment contributions as part of their regular planning process and has a procedure in place by which to enroll operators within high priority areas in water quality practices (KSRE, 2011).

3. Offsite BMPs must produce sediment credits at a rate that is less than the cost to implement the BMPs onsite. The economic analysis conducted under Task 2 demonstrates that this condition is met for any of the BMPs examined.

4. When possible, offsite BMPs that provide a greater suite of ecosystem benefits (e.g., nutrient retention, soil health improvement, habitat quality, carbon sequestration) should be favored. For instance, in many cases, conversion to no-till is likely to provide a greater environmental good through enhanced nutrient retention, runoff regulation, and soil carbon accumulation than possible through streambank stabilization projects. **The potential to improve other ecosystem services in addition to sediment retention through select offsite BMPs such as no-till through this program is viewed *very* favorably by KDHE.**

3.2.4 Spatial bounds. Most offsite water quality programs require that the offsite mitigation occurs within the same watershed. To meet regulatory expectations, we offer a similar recommendation. If the offsite program were to be administered by an external program such as WRAPS, implementation of offsite BMPs could be targeted upstream in the Little Arkansas Watershed, with prioritization to operators of erosion-prone sites nearest the watershed outlet (that is, where the sediment TMDL is monitored). Targeting offsite BMP implementation in such a spatially strategic manner is more likely to result in measurable improvements in water quality over time – a benefit that would be documented in the City's MS4 permit and which is in line with efforts of the regulatory community. As indicated in the preceding discussion of credit ratios, we recommend that land management BMPs such as filter strips and no-till be targeted to critical sediment producing areas near to the watershed outlet. Likewise, in-stream BMPs such as streambank stabilization should be targeted on banks experiencing accelerated erosion nearest the outlet of TMDL streams such as the Little Ark. There is ample opportunity for such stabilization projects in the Little Ark watershed; for instance, Hermes (2012) reports a combined sediment loading of 18,000 tons per year from eroding streambanks between Sedgwick, KS and Valley Center, which is well beyond the projected demand of 380 to 570 tons per year that could be created by the offsite implementation program. Likewise, the potential supply of sediment credits from non-permanent BMPs within the recommended spatial bounds would be adequate to meet projected sediment credit demands (Schlender and Graber, personal communication).

3.2.5 Currency of the offsite program. The currency of the offsite program refers to the stormwater constituent for which offsite mitigation is sought. This constituent is usually selected based on some water quality management target, and it is the cost of providing offsite treatment for this commodity that program costs are typically based. Other offsite stormwater programs have been developed based upon stormwater volume or nutrient load as the currency (Appendix D). In the case of the City of Wichita's program, sediment has been selected as the program currency in recognition of goals to reduce sediment loads delivered to several stream systems within the City of Wichita (e.g., Big Slough, Cowskin, Chisholm, Gypsum, Little Arkansas, and Arkansas) for which sediment-based TMDLs have been developed as listed in the City's MS4 permit. More specifically, this currency can be conceptualized as sediment credits. By implementing BMPs to reduce sediment loads, sediment-borne pollutants such as phosphorus and bacteria can also be reduced. A sediment-based program currency provides a convenient framework by which to estimate program costs in terms of sediment credits generated by offsite BMPs, in dollars per ton sediment retained, and provides a uniform commodity upon which payments into the offsite program can be based.

3.2.6 Offsite sediment credit ratios. Nearly all offsite water quality programs require the application of what is known as a credit ratio. A credit ratio refers to the amount of pollutant reduction required at the offsite location relative to that which would otherwise be required onsite. The need for such a measure arises due to uncertainties in the ratio of sediment (or other pollutant) delivery versus retention from the offsite location to the common water body of interest between the onsite and offsite locaitons (e.g., a TMDL stream). Sediment delivery from a site is controlled by slope, soil type, and, especially, the hydraulic connectivity and distance to the receiving stream (Nejadhashemi et al., 2011); therefore, the sediment reductions used in the life cycle cost-benefit analysis correspond to those likely at the edge of the field or development site, but may not be representative of the sediment load ultimately delivered from a site to a TMDL stream. Additional uncertainty in the exact performance of the offsite BMP can also be accounted for in the credit ratio. **A properly selected credit ratio balances both environmental and economic interests; the ratio should be high enough to promote environmental effectiveness to the satisfaction of regulatory interests while low enough to remain economically attractive to encourage participation by onsite properties.** In other offsite and/or trading programs, a credit ratio greater than 1:1 is typically adopted. In the context of an offsite program in the City of Wichita, a credit ratio greater than 1:1 is intended to ensure that an offsite BMP (e.g., implementation of grass filter strips by an upstream producer) achieves a comparable water quality benefit to an onsite BMP (e.g., a bioretention facility as part of a new development within the City of Wichita). Examples of credit ratios from established water quality trading programs include 2:1 for phosphorus reduction credits in Virginia's Chesapeake Bay program (Baxter, 2015), to 1.5:1 to 2:1 for offsite compliance with West Virginia's stormwater volume capture regulations (CWP, 2012). Other offsite programs have set different offsite credits for new versus redevelopment projects. For example, the City of Fredricksburg, VA was considering a credit ratio of 1.5:1 for new development and 1.25:1 for redevelopment to meet stormwater volume reduction standards offsite (CWP, 2012). **Based on consultation with KDHE, we recommend a credit ratio of 2:1 for a sediment-based offsite BMP program in the City of Wichita** (Figure 2). Assuming that offsite BMP implementation is prioritized to areas with a high potential for sediment erosion (Section 3.2.4), we have used a credit ratio of 2:1 for developing an estimate of sediment credit payment rates discussed in the following section (Section 3.2.7).

3.2.7 Sediment credit payment rate. Setting a proper payment rate for offsite sediment reductions is crucial and, to be done successfully at the program planning stage, requires an understanding of the true costs of the BMPs that will comprise the offsite BMP portfolio (CWP, 2012). The net present value of life cycle costs determined under Task 2 provide planning-scale estimates of the true costs of both urban and agricultural BMPs and can serve as the basis of an equitable fee structure that will ensure sufficient funding for both implementation and maintenance of offsite BMPs throughout the duration of an offsite program. Several approaches have been proposed for establishing payment-in-lieu type fees for offsite stormwater mitigation (CWP, 2012). The most straightforward of these is to base the payment on a "typical" BMP, that is, the BMP type that is anticipated to be most-widely used for offsite sediment reductions. With this approach, typical costs associated with the implementation of the typical BMP are used to set the sediment payment rate as a proxy for implementing a variety of offsite sediment reduction projects. Though the costs of other BMPs may be higher or lower, it is assumed that setting the fee on the selected typical BMP will split the difference, yielding a fair and equitable fee structure. The payment rate is effectively set to cover the costs to construct, maintain, and, when appropriate, replace a BMP such that the sediment reduction credits associated with that BMP can be considered perpetual.

To demonstrate how this method could be applied to the City's offsite BMP implementation program, a typical permanent and non-permanent offsite BMP will be considered here. Within the context of an offsite BMP program, a permanent BMP is defined as one for which the continued existence in the same location is fairly certain. Permanent practices could include larger structural practices such as streambank stabilization projects or permanent vegetation within a conservation easement. Non-permanent BMPs include both structural and nonstructural BMPs for which the option to remove or discontinue exists. While the credit for sediment reduction associated with nonpermanent BMPs can be considered perpetual as long as discontinued BMPs are replaced, the replacement BMP may be at a different location. Agricultural practices typically executed on a term contract (e.g., conversion to no-till, filter strips, permanent grass without an easement) represent non-permanent practices for which the landowner has the option of discontinuing at the conclusion of the contract period. In the case of the Little Arkansas WRAPS program, the most popular BMP among land-owners is conversion to no-till with intensive crop rotation (Schlender and Graber, personal communication). Although no-till is considered a non-permanent BMP, provisions can be built into an offsite BMP program such that this practice is essentially permanent within the program structure. For instance, the cost to enroll a new landowner in no-till at the end of the typical 5-year contract period can be included as a recurring cost within the life-cycle of a sediment credit supplied through conversion to no-till, and can be accounted for in the life-cycle cost calculations used to establish program payment rates. Based on experience in the Little Arkansas watershed, most landowners who enroll their land in no-till decide to continue with this practice after their contract period (5-years as currently implemented by the Little Ark WRAPS program) has expired. This is particularly true for those landowners who have used incentive funds to purchase no-till equipment. However, if the land changes ownership and/or operators, it is possible that the next operator may decide to revert the land back to conventional tillage, thus discontinuing the supply of sediment credits previously provided at that location. In cases such as this, program funds would need to be available to enroll a new operator(s) to replace the sediment credits at a different location. To build in an aspect of permanency to sediment credits generated by no-till adoption, we computed life cycle program costs for an offsite program based on no-till under the assumption that 50% of the acreage in no-till would need to be replaced every 5 years (assuming that the WRAPS program's 5-year contract period would continue to be followed). Following further discussion with the City, we also considered costs for 100% replacement of no-till acres every 5 years to include analysis of a worst-case scenario. **By building ongoing replacement costs into the cost per sediment credit, the program provides a mechanism by which to ensure the permanence of the sediment credits provided by an otherwise non-permanent BMP.** Based on previous experience with no-till adoption by producers in the watershed, the project team considers a replacement rate of 50% as a conservative estimate of no-till sediment credit replacement costs, and thus provides a mechanism by which to ensure permanence of an otherwise non-permanent BMP. Both first-time and replacement no-till costs were based on custom no-till planting rates reported for the state of Kansas (Dhuyvetter, 2014) as is standard practice. Future costs were adjusted for assumed inflation (3% annual). Details of no-till cost analysis are documented in Appendix B.

Streambank stabilization projects were selected as a typical permanent type of BMP. Although stream stabilization projects have not been implemented in a widespread manner throughout surrounding watersheds, the potential to reduce sediment loads to TMDL streams such as the Little Arkansas through stabilization projects is strong (Hermes, 2012). Furthermore, cooperating landowners are more likely to favor streambank stabilization over other permanent types of BMPs that would require placing their land in a perpetual easement (Schlender and Graber, personal communication). In developing a sediment payment rate for a permanent BMP, it is still important to ensure that the rate is set high enough to cover future maintenance, including routine management and major repairs. For planning purposes, it was assumed that major repairs (equivalent to 30% of the original construction cost plus inflation) would be required at years 25 and 50 of the stabilization projects lifetime. True lifetime costs are uncertain as there are few streambank stabilization projects that have been in place for more than 20 years. However, based on experience with existing stabilization projects in the state, it is believed that this maintenance schedule provides a conservative estimate of actual maintenance expenditures needed to maintain effectiveness throughout the lifetime of a streambank stabilization project.

Costs to generate offsite sediment credits through streambank stabilization, no-till with 50% replacement every 5 years, and no-till with 100% replacement are presented in Figures 2 and 3. Figure 2 demonstrates the scalable nature of total program costs as a function of the acreage of onsite properties participating in the program through calculation of costs for 4 participation scenarios: 600 acres/year, 300 acres/yr, 100 acres/yr, and random participation ranging from 0 to 300 acres per year. Figure 3 illustrates the cost to maintain a single ton of sediment credit, purchased in Year 1 of the program, as a function of time. Program cost analyses presented in both Figures 2 and 3 include costs incurred through the life cycle of the offsite program, and include offsite BMP construction, maintenance and/or replacement, and program administrative costs. For simplicity, inflation is not included in the data presented in Figures 2 and 3 under the assumption that the sediment credit payment rate derived from program costs would also be inflated at a similar rate as actual program costs through time. A detailed cost analysis differentiating between BMP capital, maintenance/replacement, and administrative costs with each year of the program is provided in Appendix D. Key observations from the data presented in Figures 2 and 3 include:

1. Whether based on no-till or streambank stabilization, **program costs scale with the demand for sediment credits and, thus, the cost to maintain associated sediment credits is essentially independent of the number of acres participating in the program from year to year**.

2. Sediment credits can be maintained more cost effectively via streambank stabilization over long (greater than 50 years) planning periods. ***However***, the cost per sediment credit is higher for years 0 through 40, with the initial start-up cost being approximately 2.5 times higher than no-till. In addition, streambank stabilization is not expected to provide the same diverse suite of environmental benefits as land management practices such as no-till and cover crop adoption (Table 7). Therefore, to maximize the economic efficiency of the program in the foreseeable future, we recommend utilizing no-till to generate needed sediment credits.

3. Planning to collect fees sufficient to replace 100% of no-till acres is substantially more costly than planning for 50%. **It is understood between the City, WRAPS, and KDHE that the program will be administrated with every attempt to replace non-permanent BMPs, such as no-till, that fall out of use.** Therefore, it may be appropriate to plan for a very conservative 100% replacement rate and re-evaluate this assumption (and associated sediment credit payment fees) based on the actual need for replacement acres after the program is established.

4. The cost to maintain a sediment credit generated by an offsite BMP is dependent on the program life cycle period of analysis (e.g., 50 versus 200 years). For example, a 50-year program lifetime results in sediment credit rate costs of $142, $168, and $307 per ton sediment for streambank stabilization, no-till with 50% replacement, and no-till with 100% replacement, respectively. Extending the analysis to 200 years results in credit costs of $320, $587, and $1,146 per ton sediment retained.

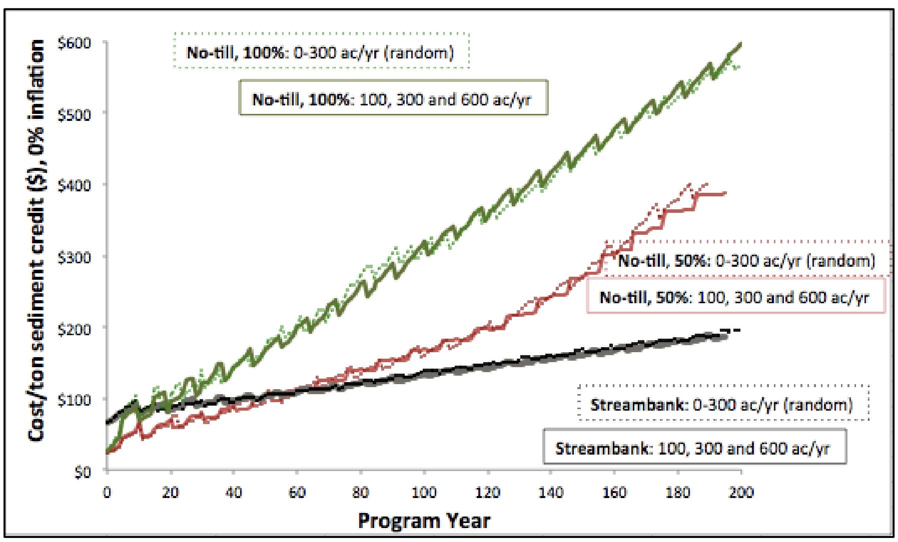

Figure 2. Cost per ton sediment credit is relatively similar regardless of onsite program participation rate. Shown here are participation scenarios of 600, 300, and 100 acres annually. Independence from participation rate persists even when annual participation is randomized, for example, between 0 and 300 acres (dashed line). In consideration of economic efficiency over the foreseeable future (< 50 years), basing program costs on no-till with a 50% replacement rate provides the greatest advantage, followed by no-till with a 100% replacement rate and then streambank stabilization.

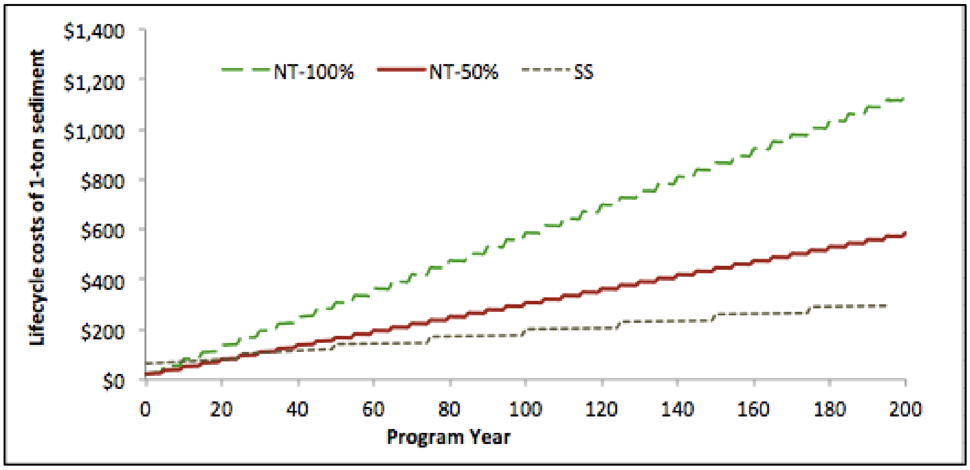

Figure 3. Cost to maintain 1 ton of sediment credits purchased in Year 1 of the program over 200 years for program costs based on offsite streambank stabilization (SS), no-till adoption with a 50% replacement rate (NT-50%), and no-till adoption with a 100% replacement rate (NT-100%). The dependence of the $/sediment credit with time creates some uncertainty in selecting a one-time fee to ensure "permanence" of that credit.

While program costs and associated credit payment rates calculated from these are relatively independent of the number of acres participating in the program from year to year, costs are dependent on the time-scale over which the sediment credit purchased is maintained. To illustrate, if a property in the City purchases 1 ton of sediment credits to offset onsite sediment generation in Year 1 of the program, that credit must be maintained "in perpetuity" to ensure the City's water quality obligations will continue to be met into the future. Therefore, the price paid by that property for 1 ton of sediment reduction offsite should cover the cost to maintain and/or replace the offsite BMP that is responsible for supplying that sediment credit. Due to the need to maintain and/or replace offsite BMPs through time, the price per sediment credit increases substantially as the period of analysis increases, with or without inflation. Of course, it is difficult to predict with any certainty program conditions in 50 years, let alone 200; however, the issue does create some challenge in establishing sediment credit fees as a one-time cost while at the same time ensuring the program does not become a financial liability to the City. As illustrated in Figure 4, setting a one-time fee that will both ensure continued maintenance of sediment credits for perpetuity while remaining at a level that is economically advantageous to onsite program participants is difficult. **Alternative options for structuring the sediment credit fee – namely as a recurring fee – are discussed further in Section 3.3.**

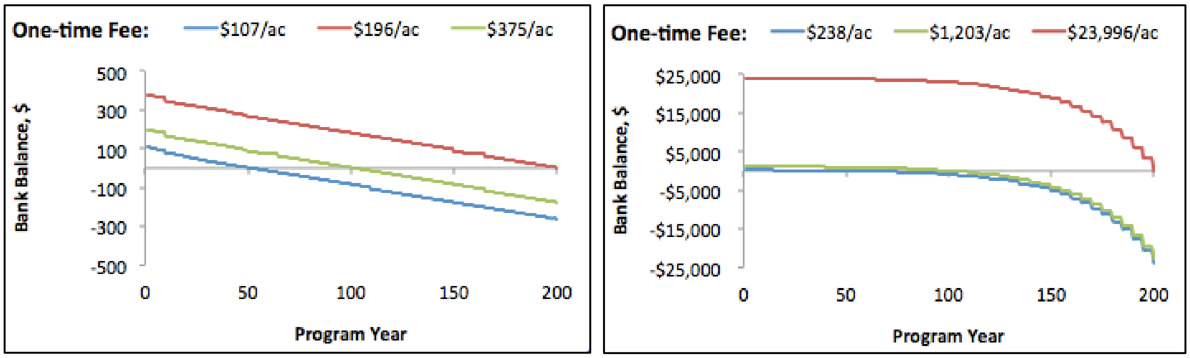

Figure 4. The predicament of the one-time fee: over what time period should sediment credits be maintained to ensure financial sustainability of the program? Taking the example of a no-till based program with 50% replacement rate, setting the fee for a 50-year period without inflation (**left graph**; $168/ton sediment or $107/acre development) results in depletion of funds to continue maintaining associated sediment credits after year 50. A similar situation arises if the one-time fee is set according to 100-year costs ($307/ton sediment or $196/ac) or 200-year costs ($587/ton sediment or $375/ac). Accounting for inflation (**right graph**) results in more extreme deficits beyond the base planning year.

3.2.8 Program Administration. Agricultural BMPs were shown to be the least cost solution, both in terms of life cycle costs of individual BMPs (Table 4) and as implemented throughout the life of an offsite program (see discussion under Section 3.2.4). To take advantage of this economic efficiency, we recommend a program model in which the City partners with an external entity that has (1) an established program in place by which to prioritize sites for BMP implementation, (2) the ability to gain cooperation from rural landowners in priority sites and (3) a system for handling financial payments to cooperating landowners. We have suggested existing WRAPS programs, such as the Little Ark WRAPS, to serve as this external entity as they have an established framework in place that meets these criteria. The City would be responsible for tracking new and re-development and collecting appropriate payments for sediment credits. These funds would be transferred to WRAPS or a comparable entity, which would be responsible for *targeted* enrollment of landowners and ensuring implementation and maintenance of offsite BMPs. **This enrollment model ensures landowners are given flexibility to select BMPs that complement their operation, but strategically targets funds to the most effective BMPs, and thus increases the economic efficiency of the program**. In addition, this model has been successfully implemented by the Little Ark WRAPS program to increase the number of soil conservation practices in the watershed (Douglas-Mankin et al., 2013). Proposed roles of involved parties are summarized in Table 10 and detailed further in the following section.

Table 10. Responsibilities associated with recommended program administration
Onsite Property (Developer and/or Owner) ▪ Notify City of intent to participate in offsite program ▪ Provide documentation of expected sediment load generated by new or re-development using approved models ▪ Provide appropriate payment to City based on program credit ratio and sediment payment rate
City of Wichita ▪ Review onsite sediment generation submitted by developer for new or re-development project ▪ Document onsite sediment generation and offsite compliance requirement ▪ Collect payment for offsite compliance from onsite party(ies) according to sediment payment rate ▪ Transfer sediment payments to WRAPS on recurring schedule (e.g., bi-annually) to fund offsite BMP implementation projects
WRAPS or similar watershed entity ▪ Identify and enroll prioritized landowners in combination of perpetual and/or non-perpetual sediment reducing BMPs to achieve annual sediment reduction *no less than* annual expected sediment reduction demand from new and re-development projects in Wichita. It is expected that the cumulative supply of sediment credits generated offsite remains ahead of onsite demand. ▪ Conduct annual field checks of enrolled BMPs to ensure sediment credits maintained; enroll replacement BMPs as necessary. ▪ Maintain sediment credit database documenting BMPs implemented in each program year, offsite BMP types and acreage, predicted sediment reduction achieved, dates of inspection and program funds utilized. The continuation of offsite BMPs implemented through this program should be confirmed by site visits at the time of annual recurring payments to landowner as per the existing WRAPS protocol (Appendix E) ▪ Deliver database documentation annually to the City of Wichita to satisfy City's MS4 permit reporting requirements ▪ Provide City with 1-page summary to annually to communicate to onsite program participants work achieved offsite with sediment credit fee payment

To the extent possible, existing administrative structures can be utilized to minimize administrative program start-up costs. Given the success of the current WRAPS framework for prioritizing, implementing, and monitoring BMPs, we recommend that an offsite BMP program for the City of Wichita be administered similarly. In terms of *offsite BMP prioritization,* priority areas for BMP implementation within each WRAPS watershed have already been identified through the WRAPS 9 Element Plan, which is a document outlining specific strategies to meet water quality targets within the watershed (e.g., KSRE 2011; River City, 2013). Using this enrollment approach, the Little Arkansas WRAPS program was able to enroll approximately 5,080 acres in water quality BMPs (predominately conversion from conventional to no-till tillage practices) over a 3-year period. Assuming sediment reductions typical of no-till, this 5,080 acres equates to about 16,000 tons of sediment, or enough to supply roughly 80% of the sediment reduction credits demanded by new and redevelopment in Wichita over a 50-year period assuming an average growth rate of 600 acres per year. This demonstrates the capacity of the WRAPS framework to supply a large credit demand over a short time frame by effectively implementing BMPs.

As related to the sediment-based program of interest here, the Little Arkansas WRAPS has established a process for identifying target areas for sediment reduction (Douglass-Mankin et al., 2013). With respect to the process for *offsite BMP implementation,* the existing WRAPS process could also be utilized. After a property is identified as a priority area for BMP implementation, WRAPS staff members meet personally with associated landowners and/or operators to discuss BMP options, available incentive payments, and maintenance contracts. Landowners typically opt to enroll in one or more BMP options, such as no-till with intensive crop rotation or grass filter strips, during this visit. Under their current model, WRAPS staff utilize a field sign-up worksheet (included in Appendix E) to communicate eligible BMPs and the incentive payment associated with each to program participants. Incentive payments are based on the sediment retention rate expected for each BMP type such that more efficient BMPs are eligible for greater incentive payments. A similar field sign-up approach could be utilized by the City's offsite program and follow a similar incentive payment structure based on the sediment payment rate established for the program (see Sections 3.2.4 and 3.3 for discussion) to include only those BMPs which the City grants eligibility (see Sections 3.2.3). *Offsite BMP sediment credit tracking* would also be the responsibility of the external entity. Under the existing WRAPS system, incentive payments are made on an annual basis, typically over a 5 to 10 year contract period, and are delivered following a visit by a WRAPS agent, thus providing a mechanism to monitor for the continued existence of contracted BMPs. This approach could be adapted to an offsite stormwater BMP program by adding a process for the continued monitoring of BMPs (or, really, the sediment credits they generate) beyond the short-term contract period. As discussed in Section 3.2.4, most landowners opt to continue with contracted BMPs, particularly for conversion to no-till. Continued monitoring of such practices is included in the recurring administrative costs accounted for in developing programmatic cost estimates associated with both permanent and nonpermanent; thus, payments into the program for sediment credits provide funding to WRAPS personnel for continued monitoring and accounting of offsite BMPs implemented through the program.

The external entity would also be responsible for reporting to the City annual expenditures of program funds, BMPs implemented and the sediment reduction credits generated. These accounting requirements are not significantly different from the reporting expectations existing WRAPS programs have to government agencies that fund WRAPS activities (e.g., KDHE). A protocol for documenting long-term persistence of sediment credits (the permanence of which could be accomplished through continued maintenance of a BMP at the same spatial location or through replacement of BMPs at different locations within the same watershed) would need to be developed. A spatial database could be developed relatively easily using GIS tools to facilitate sediment credit and offsite BPM tracking.

With responsibilities of offsite BMP prioritization, implementation, monitoring and reporting resting on the external entity, administrative responsibilities of the City relate primarily to collecting sediment credit payments from program funding sources (discussed under Task 4) and then transferring these funds to the external entity on a recurring time interval (e.g., monthly or annually). The City would also be responsible for certifying the magnitude of sediment credit payments. To the extent possible, certification mechanisms can be built into existing processes. For example, the option to participate in an offsite stormwater program could be added to existing stormwater permit paperwork already required by the City for new and redevelopment projects. Developers/property owners who opt to participate in the program would indicate so, and then provide additional information (e.g., impervious surface acreage) that could be used to develop a simplified estimate of post-development runoff sediment generation from the project site. For example, the City could adopt an estimate of 0.32 tons per acre new or redevelopment (equivalent to about 0.5 tons per impervious acre) as based on national stormwater runoff data and local precipitation characteristics (NCHRP, 2014) and as assumed in the analyses herein. Depending on the funding sources identified for this program, the City would then be responsible for notifying relevant onsite parities of their contribution to purchase sediment credits generated by offsite BMPs. Given suggested reporting responsibilities of the external entity to the City, the City would be able to ensure that the supply of sediment credits produced by offsite BMPs already implemented through the offsite entity is greater than total sediment credits paid into the program by onsite parties.

3.3 Program Fee Structure and cash flow: annual versus one-time

Based on discussion with members of the SWAB, a 10-year reserve of sediment credits is desired to assure a sufficient supply of readily available sediment credits and avoid interruption in development activities. To adequately front-load the program, a sediment credit "bank" would be established in Year 0 of the program with funds sufficient to finance a 10-year supply of sediment credits by Year 1 of the program. These funds would be transferred to WRAPS, which would then be responsible for spending these funds on targeted water quality BMP projects as needed to accumulate the required 10-year supply of sediment credits prior to making the option for offsite BMP implementation available to new and redevelopments in Year 1. Following this initial infusion of capital, fees will be paid into the bank by program participants. As development occurs, the initial sediment credit bank will be allowed to draw down but a "cushion" should be maintained to ensure the bank of available sediment credits remains ahead of onsite sediment production. As discussed in Section 3.2.7 structuring sediment credit payments solely as a one-time fee introduces uncertainty that the program can remain financially sustainable over any time span. **Based on discussions with the City of Wichita, a recurring fee is more highly favored to ameliorate concerns of adequate cash flow throughout the duration of the program.** Owing to its foundation in sediment credits, it should be noted that regardless of the number of onsite acres participating from year to year, the annual fee to participate in the program remains fairly consistent as the number of offsite acres scales accordingly with the number of onsite acres.

A spreadsheet tool has been developed to calculate program costs and cash flow as a function of user inputs, which include assumptions regarding the quantity of sediment produced onsite, the required Offsite sediment to Onsite sediment credit ratio, an implementation ratio which affects the pace at which offsite BMPs are implemented (i.e., the "cushion" to ensure the offsite credit supply remains ahead of onsite demand for credits), the percentage of BMPs replaced, annual inflation, City growth rate and associated number of onsite acres participating in the program, and the sediment credit payment rate (Figure 5). Based on the computed cash flows and program variables, the user can adjust the sediment credit payment rate to ensure that the program generates sufficient funds to transfer to WRAPS for required offsite BMP implementation and maintenance. **The spreadsheet can be a tool used by the City of Wichita to determine program costs and an annual fee to be charged to developers who participate in the program.** In setting an annual fee, the goal is to set the fee such that the bank does not go into debt and the initial start-up funds can be repaid in a timely manner if necessary. **To ensure the**

financial sustainability of the program, it is important that the City has the flexibility to adaptively manage program fee structures. It is recommended that the City review program fee structure periodically and adjust as necessary.

To illustrate this tool's use, the following example is given. An average of 200 acres of properties within the City elect to participate in the program each year. An annual fee of $47 per ton of sediment ($37.60 per participating onsite acre) is charged each year, with a fee decrease to $9 per ton sediment ($7.20 per participating onsite acre) in Year 8. Other program inputs are displayed in Figure 5, with the resulting cash flows paid into the program's sediment credit bank through annual fees paid and out of this bank to WRAPS to fund required offsite BMP implementation and maintenance presented in Figure 7 in Table 11. The resulting balance between onsite sediment produced and offsite sediment credits supplied is illustrated in Figure 6.

PROGRAM ASSUMPTIONS of sediment removal by offsite BMPs						
Sediment credit No-Till	3.2	tons/ac/yr				
Sediment credit streambank stabilization	589.9	tons/ac/yr		1.7	tons/linear ft/yr	
USER INPUTS						
Onsite Sediment produced	0.4	tons/ac/yr				
Offsite:onsite credit ratio	2	:1				
% no-till fields replaced	100%	every 5 years				
No-till sediment credit "cushion"	1.1	(affects pace at which no-till implemented to remain ahead of onsite sediment production)				
Starting fee all acres to date, $/ton sed.	$ 47.00			$ **37.60**	Annual Cost/acre under initial fee	
Inflation rate, annual program costs	**0.00%**					
Inflation rate, annual fee	0%	per year				
City growth rate, year 1	200	acre	Avg annual growth, ac/yr	200	City participation rate	*100%*
Interest rate on start-up funds	0%	annual	# compounded/yr	12	payback period (yrs)	10

Figure 5. User inputs to spreadsheet tool developed to allow the City to determine program costs and appropriate fees to be charged to developers who participate in the program.

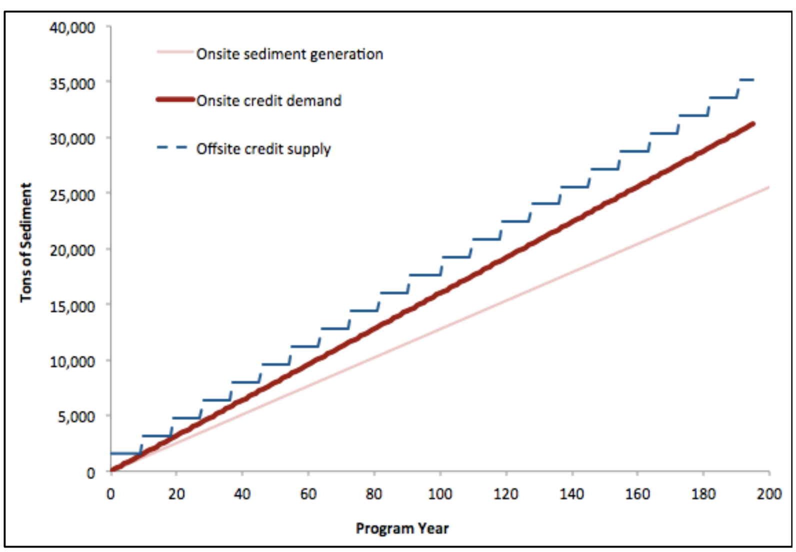

Figure 6 For the case of 200 acres of onsite properties enrolling in the offsite program each year, the associated onsite sediment production, onsite sediment demand assuming 2:1 sediment credit ratio, and sediment credits supplied offsite via offsite BMPs. In addition to starting the sediment credit bank with a 10-year supply, an additional implementation "cushion" may be specified in the spreadsheet tool to ensure offsite BMPs and associated sediment credits are implemented ahead of onsite demand. In the case illustrated here, a value of 1.1 was specified.

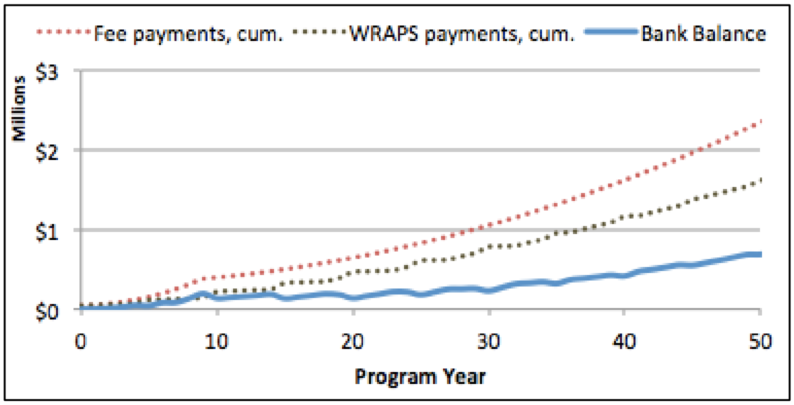

Figure 7. Sediment credit bank balance (solid blue line) for the program inputs given in Figure 4. The bank balance reflects the difference of funds paid to the program via an annual fee charged to properties participating in the program (dotted red line) and payments to WRAPS (or similar external entity) for BMP implementation (dotted brown line).

Table 11 (following page). Cash Flows to and from "sediment credit bank" as computed via spreadsheet tool for a scenario in which 200 acres of properties within the City opt in to the offsite program each year. Table columns are labled as **A.** the program year, **B.** the number of new acres joining the program, **C.** the demand for offsite sediment credits from participating onsite acres each year (onsite sediment production x 2), **D.** Sediment credits supplied offsite via offsite BMPs; **E.** Cash flow from onsite acres to the Sediment Credit "Bank" via annual fee structure, **F.** Cash flow to WRAPS (or comparable offsite entity) to install and maintain BMPs to supply sediment credits indicated in C., **G.** The Sediment Credit Bank balance (columns E. minus F.), **H.** Repayment amount of start-up funds.

A. Year	**B.** New Acres participating per year	**C.** Onsite sediment production x 2:1 credit ratio, tons/yr	**D.** Offsite sediment credit supply (tons)	**E.** Cash flow to Sediment Credit "Bank"	**F.** Cash flow to WRAPS/ offsite entity	**G.** Sediment Credit Bank balance	**H.** Start-up Repayment amount
0	0	0	1600	$41,830 [a]	$41,830.40	$-	
1	200	160	1600	$7,520	$7,430.40	$90	$-
2	200	320	1600	$15,040	$7,430.40	$7,699	$-
3	200	480	1600	$22,560	$7,430.40	$22,829	$-
4	200	640	1600	$30,080	$7,430.40	$45,478	$-
5	200	800	1600	$37,600	$41,830.40	$41,248	$-
6	200	960	1600	$45,120	$7,430.40	$78,938	$-
7	200	1120	1600	$52,640	$7,430.40	$124,147	$41,830
8	200	1280	1600	$60,160	$7,430.40	$176,877	$-
9	200	1440	1600	$67,680	$7,430.40	$237,126	$-
10	200	1600	3200	$75,200	$76,230.40	$194,266	$-
11	200	1760	3200	$82,720	$7,430.40	$269,555	$-
12	200	1920	3200	$90,240	$7,430.40	$352,365	$-
13	200	2080	3200	$97,760	$7,430.40	$442,694	$-
14	200	2240	3200	$105,280	$7,430.40	$540,544	$-
15	200	2400	3200	$112,800	$76,230.40	$577,114	$-
16	200	2560	3200	$120,320	$7,430.40	$690,003	$-
17	200	2720	3200	$127,840	$7,430.40	$810,413	$-
18	200	2880	3200	$135,360	$7,430.40	$938,342	$-
19	200	3040	4800	$142,880	$41,830.40	$1,039,392	$-
20	200	3200	4800	$150,400	$76,230.40	$1,113,562	$-
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
190	200	30400	35200	$1,428,800	$223,600	$117,347,530	$-
191	200	30560	35200	$1,436,320	$223,600	$118,560,250	$-
192	200	30720	35200	$1,443,840	$178,880	$119,825,210	$-
193	200	30880	35200	$1,451,360	$178,880	$121,097,690	$-
194	200	31040	35200	$1,458,880	$178,880	$122,377,690	$-
195	200	31200	35200	$1,466,400	$223,600	$123,620,490	$-
196	200	31360	35200	$1,473,920	$223,600	$124,870,810	$-
196	200	31520	35200	$1,481,440	$178,880	$126,173,370	$-
198	200	31680	35200	$1,488,960	$178,880	$127,483,450	$-
199	200	31840	35200	$1,496,480	$178,880	$128,801,050	$-
200	200	32000	35200	$1,504,000	$223,600	$130,081,450	$-

[a] Assumed start-up funds supplied by the City and/or other external source (see Section 4.3) provides initial cash infusion to program. Spreadsheet tool provides options for repayment of start-up funds.

The same analysis can be applied to demonstrate the effect of inflation. We assume a 3% annual rate of inflation, and that the sediment credit payment rate would be inflated at a comparable pace. User inputs to the spreadsheet are presented in Figure 8, and resulting cost analysis in Figure 9.

PROGRAM ASSUMPTIONS of sediment removal by offsite BMPs						
Sediment credit No-Till	3.2	tons/ac/yr				
Sediment credit streambank stabilization	589.9	tons/ac/yr	1.7	tons/linear ft/yr		
USER INPUTS						
Onsite Sediment produced	0.4	tons/ac/yr				
Offsite:onsite credit ratio	2	:1				
% no-till fields replaced	100%	every 5 years				
No-till sediment credit "cushion"	1.1	(affects pace at which no-till implemented to remain ahead of onsite sediment production)				
Starting fee all acres to date, $/ton sed.	$ 47.00			$ **37.60**	Annual Cost/acre under initial fee	
Inflation rate, annual program costs	**3.00%**					
Inflation rate, annual fee	3%	per year				
City growth rate, year 1	200	acre	Avg annual growth, ac/yr	200	City participation rate	*100%*
Interest rate on start-up funds	0%	annual	# compounded/yr	12	payback period (yrs)	10

Figure 8. User inputs for case in which 200 acres per year participate in the offsite program. Program costs are assumed to inflate 3% per year. The "Starting fee all acres to date" and "Reduced fee for all subsequent years" are set by the user to ensure that the bank balance (Figure 9) remains positive in all program years.

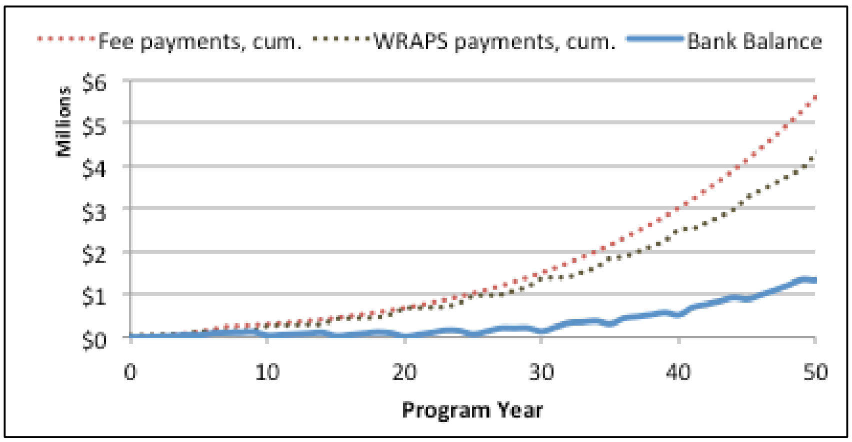

Figure 9. Sediment credit bank balance (solid blue line) over a 50-year program for inputs specified in Figure 8. The bank balance reflects the difference of cumulative payments into the bank through annual fees (initially $37.60 per acre per year) and cumulative payments from the bank to WRAPS to fund water quality BMP implementation and maintenance.

The economic incentive to developers and/or property owners for participating in an offsite water quality BMP program is illustrated in Figure 10. Here, we compare the costs to a small-scale commercial property (1-acre) and a larger-scale residential development (40-acres) development to meet post-construction water quality requirements onsite versus offsite. For both cases, only the incremental costs to provide water quality beyond the minimum onsite requirements (i.e., hydraulic and trash control; see Section 3.2.2) are considered. For the 1-acre commercial property, we assume a hydrodynamic separator would be used to meet onsite water quality requirements as these devices are typical of such developments in the City. At a minimum, capital costs associated with onsite treatment are projected to be $22,500 for the purchase and installation of the device (Appendix A). For the larger residential development, we estimated the incremental costs of a wet detention basin with a water quality volume of 1.6 acre-ft. The additional volume and specialized outlet structure required to gain water quality function are assumed to cost $54,464 more than a basin for peak rate control only (Appendix A). For both properties, the biannual inspection required by the City is assumed to cost $500. Participation in the offsite program will cost $37.60/ac/year based on minimum initial acreage charges for a no-till based program with 100% replacement. In this case, there is a clear advantage to the small development, and 40-years of cost savings to the larger residential development.

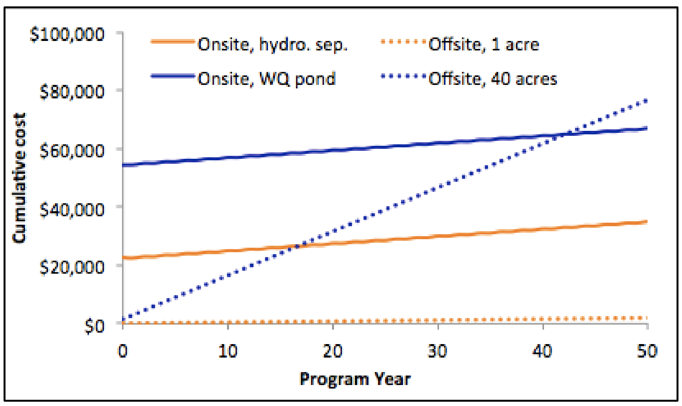

Figure 10. Comparison of costs to meet water quality requirements onsite versus offsite for a hypothetical 1-acre commercial development and 40-acre residential development. Onsite water quality requirements for the commercial development are assumed to be met with a hydrodynamic separator (Onsite, hydro. sep.); a wet pond with 1.6-acre water quality volume is assumed for the residential site (Onsite, WQ pond). Cost for offsite alternative ($37.60/ac/yr) are shown by the dotted lines.

The sediment credit fee will influence participation in the program. If the program budget were developed to cover replacement of 50% of no-till acres enrolled in the program (a scenario also considered to be conservative based on the project team's experience working with land owners in the watershed), then the annual fee could be set to $28/ton sediment per year ($22.40 per acre per year). This may induce greater participation of larger-scale developments. Regardless of the annual fee amount, we expect the program to provide a substantial economic advantage to smaller properties while larger scale developments will need to evaluate cost-benefits on a case-by-case basis.

Task 4. Develop program funding options

The goal of this task was to develop a suite of potential funding mechanisms by which the life cycle costs associated with offsite BMP implementation can be financed *in perpetuity*. As indicated in 8, sources of funding to offsite water quality programs may vary widely, from the developer only, to the City only, to a mixture of both private and public sources. Whatever the funding source(s) may be, the goals of the funding portfolio are similar, and include:

1. ensuring that parties that benefit from the program contribute to funding it. In the case that public funds are utilized, public benefit must be demonstrated.
2. ensuring the process by which parties pay into the program is transparent
3. ensuring that the funding source is sustainable such that the program can continue to function

With these goals in mind, the parties that could be responsible for paying program sediment credit rates developed under Tasks 2 and 3 are discussed in the following sections.

4.1 Current funding structure for onsite BMPs

Before considering potential funding sources for an offsite BMP program, it is instructive to consider the mechanisms that are currently in place to fund BMP implementation and maintenance. Such consideration allows identification of current funding sources as well as the parties that could directly benefit from participation in an offsite BMP program. Currently, the developer of a new or redevelopment project is responsible for all costs associated with implementing water quality BMPs onsite, such as the design, permitting, construction, surety bonds, and related administrative costs. Following BMP implementation, maintenance responsibilities are typically shifted to the property owner or a related party (e.g., Home Owner's Association). As part of their MS4 permit requirements, the City requires documentation of proper BMP maintenance every two years. To obtain this documentation, the City notifies the property owner and provides appropriate forms to report maintenance activities. Maintenance documentation is typically provided by an external BMP maintenance provider that has been contracted by the owner.

Based on onsite water quality BMP financial responsibilities, the parties that could directly benefit from an offsite program include developers, assuming that the cost to participate in the offsite program is less than the cost associated with onsite BMP implementation, and future property owners, assuming their cost to participate is less than the cost to assure maintenance obligations are met.

4.2 Potential funding sources for offsite program

At their October 2014 monthly meeting, the Wichita Stormwater Advisory Board (SWAB) brainstormed advantages and disadvantages associated with funding the program solely with public funds or solely with private (developer) funds (Table 12). As indicated by the discussion generated among SWAB members, there are potential advantages and disadvantages associated with either public or private funding sources. Among the primary disadvantages of a completely City-funded program is the difficulty in clearly defining direct benefits to all tax-paying citizens. Of the offsite water quality programs that were reviewed under Section 3.1, two were fully funded by City government. Both of these programs were related to public drinking water supplies, for which the overall public benefit is clear. The Lenexa "Rain to Recreation" stormwater program included a public element through both a sales tax and stormwater utility fee along with a developer use charge. In Lenexa's program, offsite BMPs consisted of regional retention (lakes) throughout the city that were accessible for public recreation and were thus considered as an amenity by the general public. In the case of an offsite BMP program in which BMPs are located in upstream agricultural areas on private lands, the public benefit – which, albeit, would include improved downstream water quality within the City's rivers – is more difficult to communicate to the general public. Nonetheless, both public and/or private funding sources are likely to be appropriate for an offsite BMP program in Wichita. Both types are summarized in Table 13, and are explained in further detail in the following sections. **The City has expressed preference for an annual fee structure**; however, one-time payment options are also presented for the sake of completeness.

Table 12. Advantages and disadvantages of City (Public) versus Developer (Private) funded offsite BMP program. Developed from brainstorming by Stormwater Advisory Board members, October 2014.
City-Funded *Advantages* ▪ Creates developer friendly environment ▪ Potentially more efficient and effective (i.e., not dependent upon pace of development) ▪ Enables long-term planning ▪ Higher density/use of land ▪ Increased flexibility of funding options and/or use of other credit sources *Disadvantages* ▪ User fees are typically preferential to government funding ▪ Must develop policies for those grandfathered in to program ▪ Transitional challenges ▪ New budget item ▪ Difficult to "sell" program to taxpayers
Developer-Funded *Advantages* ▪ Maintains current practices ▪ Enables use of "user only fee" ▪ Fees not managed by City ▪ Do not have to try to "sell" to taxpayers ▪ Conforms to current EPA/KDHE model *Disadvantages* ▪ Viewed as punitive to new development/redevelopment ▪ Up-front costs of program must be addressed to implement offsite BMPs ahead of onsite development activities ▪ Must ensure recurring program costs covered in fee to developers, which is likely to be a one-time fee

Table 13. List of potential funding mechanisms and the source of funding (developers versus citizens) targeted.

Funding mechanism	Type of charge	Targeted party
Capital charge (Impact fee)	One-time	Developers of new and redevelopments who opt in to offsite BMP program
System Development Charge	One-time	Citizen; targeted to owners/residents of new and redevelopment properties participating in offsite BMP program
Special Assessment	Recurring	Citizen; targeted to owners/residents of new and redevelopment properties participating in offsite BMP program
Stormwater Utility	Recurring	Citizens; can be targeted to participants in offsite program applied across all citizenry
Property Tax	Recurring	Citizens; can be targeted to participants in offsite program applied across all citizenry
Local Sales Tax	Recurring	Citizens, applied across all citizenry

4.2.1 Capital Charge (Impact Fee). A capital charge, or impact fee, could be assessed to new and redevelop in the same fashion that the City currently charges for other types of infrastructure needed to accommodate growth. Without the option of an offsite program, all developers are required to install water quality BMPs to treat stormwater from new and redevelopment projects. With the proposed capital charge, developers would pay a capital charge when they apply for a building permit in order to opt in to the offsite BMP program. This charge would be based on the projected sediment load a new or redevelopment project may deliver.

This funding mechanism would be similar to the in-lieu fee charged to developers who opt to meet water quantity or quality obligations off site in other offsite programs administered by MS4s (Appendix D), and thus, there are models in place for the administration of this type of charge. This funding mechanism also provides a means by which the development community can contribute to the financial support of an offsite BMP program if they stand to benefit from participation. Capital charge fees are assessed only once. For this reason, it is important to base the magnitude of this fee on the net present value of the lifecycle costs associated with implementing and maintaining sediment reduction credits. Mechanistically, capital charge fees are feasible; however, for this funding source to be successful, the capital charge should not increase the costs of development.

4.2.2. System Development Charge. Traditionally, system development charges (SDC) refer to the on-time fee commonly charged to new stormwater customers being connected to the existing stormwater infrastructure to *buy in* to the infrastructure already built for them and/or necessary to expansions to accommodate them. As such, an SDC is a citizen-based charge that is somewhat analogous to the capital charge that could be assessed to developers. The magnitude of an SDC is typically determined based on the amount of stormwater (or pollutant load) a property will generate, and is typically tied to the impervious surface area of the property (EPA, 2008). An advantage of this funding mechanism is that it can be targeted to only those programs directly involved in the offsite BMP program. As with the developer-based capital charge, an SDC is a one-time fee and thus needs to account for the net present value of the lifecycle costs associated with implementing and maintaining sediment reduction credits.

4.2.3. Special Assessment. A special assessment refers to a charge that is assessed only to those properties that benefit from a particular construction project or program. For example, residents of new developments are often subject to special assessments for new roads and/or water and sewer infrastructure extended by the City. This type of charge could be adapted for an offsite BMP program to target only those properties that have opted in to the offsite program (and thus, do not bear financial responsibility for onsite water quality BMP maintenance). The targeted nature of a special assessment fee is a potential advantage of this funding mechanism for an offsite BMP program. Most special assessments eventually sunset; thus, the time period over which a special assessment-based funding source would be collected would need to be negotiated.

4.2.4. Stormwater utility. The City of Wichita established a Stormwater Utility, approved by the City Council, to fund construction and maintenance of City-provided stormwater infrastructure. To fund installation and upkeep of this infrastructure, all residential properties in the City pay $2 on top of their monthly water bill, while commercial properties pay $2 per equivalent residential unit (ERU, where one ERU is equal to 2,139 ft^2 impervious surface area on the property). One advantage of a stormwater utility as a funding mechanism is that they provide an equitable fee structure in which parties are charged based on their potential to generate stormwater runoff and associated pollutant load as based on impervious surface cover rather than property value or other equity measure. The fee structure could be adjusted to target only those properties participating in the offsite BMP program. A stormwater utility also provides a dedicated funding source.

If the City's existing stormwater utility program were to be used to provide a funding stream to the offsite BMP program, it is likely that the fee structure would require revision to increase fees for either all rate payers or only those directly associated with new and redevelopment properties utilizing the offsite BMP program. A rate increase is likely to be necessary since the City's commitment to provide and maintain drainage infrastructure to new developments and across the City is not likely to change, and thus, will continue to require the dedicated funding source provided by the existing stormwater utility. A change in stormwater utility rates would require action from the City Council with opportunity for public comment. If reallocation of existing stormwater utility fees were desirable, preliminary economic analysis by members of the project team have indicated that substantial cost savings could be achieved through establishing no-mow zones along streams and drainage ditches (e.g., River City, 2012). The establishment of no-mow zones also aligns with the City's MS4 permit as establishment of (native) grasses is also believed to contribute to water quality and improve soil stability. Whether potential cost-savings could be reallocated to fund a portion of the offsite BMP program would require additional study.

4.2.5. Property Tax (General Funds). General funds are raised through taxes assessed based on the value of a given property, and represent the majority of the dollars available to the City to fund public services such as maintenance of roads, parks, schools, and other municipal programs. In addition to the fierce competition for general funds, there are other aspects of a property tax-based funding mechanism that may not provide the best fit to an offsite BMP program. First, the quantity of stormwater and its associated pollutant load that a property generates is not necessarily related to the value of that property; thus, the fee structure of a property tax is not the most equitable for determining payments to an offsite stormwater program. Second, tax-exempt properties such as schools and governmental properties are often large stormwater contributors, but a property tax would not provide a mechanism to for these properties to contribute financially to an offsite stormwater program. For these reasons, a property tax is probably not the most feasible means by which to obtain program funding.

4.2.6. Sales Tax. Some offsite water quality programs have been successful in securing funding through a dedicated local sales tax. As an example, the citizens within the City of Lenexa, KS, approved a 1/8% sales tax measure to support the City's "Rain to Recreation" program in which onsite green infrastructure and riparian setbacks and offsite regional retention were utilized as a more economically efficient means of providing stormwater quality and quantity control within the City. The sales tax measure was approved for 5 years, and then reapproved for an additional 5 years by the citizen voters. As a direct benefit of funding this measure, voters received the benefit of access to recreational trail and lake access created by regional retention basins. A similar dedicated sales tax was recommended to the Sedgwick County Public Works Department establish dedicated funding for stormwater management projects (PBA et al., 2010).

An advantage of a sales tax funding mechanism is that it is a dedicated funding source that will be sustained over a set time period. It is, however, a non-targeted funding mechanism, which may be a disadvantage in the case of an offsite BMP program in which the public benefit to all citizens is not as clear. Any sales tax measure would need to be balloted and approved by public voters. As demonstrated by the recent November 2014 vote, in which citizens did not approve a local sales tax to support drinking water infrastructure, public support for sales tax measures is likely not to be high. Thus, a sales tax may not be the most feasible funding mechanism.

4.2.7. Recommendations regarding potential funding sources. The SWAB asked the consulting team to provide an opinion about which party or parties should pay for the program. Because the program is designed specifically to meet Clean Water Act requirements for post-construction water quality protection, the project developer should fund at least the portion of the in-lieu fee covering the capital costs of water quality improvements. A case can be made that the property owner pay for the longer-term operations and maintenance costs, whether a commercial, industrial or office development, or a homeowners association (HOA). In addition, during the March 13 SWAB meeting it was asked whether ratepayers generally should fund the program. The ratepayers will not directly benefit from the program; and while protected water quality is an indirect benefit, the program is designed to mitigate the direct impacts of new development and redevelopment to protect existing water quality, rather than provide a general improvement in water quality. Furthermore, it was noted in the meeting that stormwater management needs exceed current revenues, and adding the cost of water quality credits would further reduce funding for long-term needs. However, the question of whether the City should fund this cost as a *development incentive* is a policy decision that is beyond the scope of this study.

4.3 Program Establishment: securing startup funding

To meet the expectation that implementation of offsite BMPs, and thus the supply of sediment credits available to offset onsite sediment production *ahead of* development, an initial source of funding must be secured. The SWAB has expressed its desire that the initial funding pool would provide a 10-year reserve of sediment credits to assure a sufficient supply of readily available sediment credits and avoid interruption in development activities. Only a portion of the funding sources identified above provide a mechanism by which to accumulate an adequate reserve of program funds ahead of development, and these would necessarily be applied across all citizens: stormwater utility, property tax, and sales tax. Given that the intent is to jumpstart the "bank" from which offsite BMPs can be funded, but not necessarily to maintain program funding, this funding source could be temporal in nature.

Through some combination of existing funds, the City has expressed that it would be amenable to providing day one funding to the bank (J. Hardetsy, personal communication). If this initial 10-year bank of sediment credits were bonded, the calculations to pay back the bond with interest in a specified timeframe is built into the spreadsheet tool provided to the City to ensure that fees paid into the program are sufficient to fund offsite BMP implementation, maintenance, and interest payments.

External funding sources may be available to match funds put forth by the City for program start-up. Project partner Vireo posed a general inquiry regarding the possibility to obtain assistance from the Urban Watershed Federal Partnership (UWFP). The UWFP includes over a dozen federal agencies and multiple non-governmental organizations, and aims to stimulate regional and local economies, create local jobs, improve quality of life, and protect Americans' health by revitalizing urban waterways in under-served communities across the country. Partners target and coordinate their technical, organizational and limited financial resources to support innovative urban watershed protection efforts. While federal partnership projects in other regions (including Kansas City and St. Louis, Missouri) are site-based, the UWFP is generally interested in innovative projects and programs. One important benefit is the ability to receive headquarters-level approval and support for innovative or unusual proposals and approaches. The City should formally inquire with the UWFP after it proposes the program to EPA Region 7.

Based on a similar general inquiry, it appears that the EPA Region 7 Water program is increasingly supportive of innovative water quality protection programs, particularly those that support or enhance Total Maximum Daily Load (TMDL) compliance efforts. The consulting team can help the City approach key contacts at Region 7 to build support for the proposed offsite program. For example, EPA's UWFP Ambassador for the St. Louis project previously worked in the TMDL section and might be helpful both at the regional and headquarters level.

Once program start-up funds are secured, fees paid into the program by developers and/or property owners are intended to secure the program's operation and maintenance. An additional surcharge for longer-term program operations and maintenance could be added to the initial credit price and placed in an escrow account. Accrued investment earnings would be used to fund long-term program needs. Finally, the assumptions documented in the report are based on assumed conditions over the proposed program lifetime, and represent average conditions over that timeframe. However, a significant opportunity exists if initial efforts are "front-loaded". The cost and environmental benefit of implementing rural, off-site BMPs will be significantly lower at project inception and will only increase over time.

Summary

This report documents a framework for establishing an offsite water quality BMP program. Key considerations in developing this implementation framework are summarized in the following:

External versus internal program management. In considering an internally managed program, the project team first considered the question of whether water quality credits could be generated from City investments in water quality improvements on urban projects. As the study documents, the City has previously committed to a number of water quality improvements under its Municipal Separate Storm Sewer System (MS4) permit. In order to claim water quality credits from its improvement or operations and maintenance programs, the City would have to document that the improvements or programs were in addition to those required by the MS4 permit. In addition, the improvements or programs should have a clear water quality purpose with estimated results that can be quantified or tied back to empirical research or data. For example, the City could add water quality stages to a detention basin project, or could create new incentives or new regulations and enforcement programs for activities that degrade water quality and are not currently covered by the MS4 permit. However, as documented in Section 2.2, the relative cost to retain sediment in the urban landscape versus the rural is substantially higher. Therefore, the project team recommends administering the program through an external entity with connections to producers in the surrounding agricultural lands. We specifically recommend the Little Arkansas WRAPS program as the external program manager since this program (1) has an established record working with landowners to implement water quality BMPs, (2) has mechanisms in place to prioritize BMP implementation to lands most susceptible to erosion, thus increasing the economic and environmental efficiency of the program, and (3) has the infrastructure in place to receive payments from the City and distribute to landowners.

Eligible offsite practices. Successful water quality market programs have documented gains in the economic efficiency of programs in which offsite participants are given flexibility to select water quality BMPs of their choice. Therefore, we recommend structuring the program such that landowners may select from a suite of BMPs and will then receive incentive payments based on the expected sediment reduction (and, thereby, the supply of sediment credits) achieved by a given practice. We recommend basing the value of sediment credits on the cost to implement no-till given (1) the relative popularity of this practice among landowners and thus, the likelihood that it will be implemented and (2) the preference of regulatory agencies for land management practices such as no-till that provide multiple environmental benefits in addition to sediment reduction. To meet the City's criteria for perpetual function of the program, the project team built in the assumption that a specified fraction of no-till acres will be replaced every five years following the typical contract period under which WRAPS currently disperses incentive payments. Based on the team's experience with long-term no-till adoption in the Little Ark watershed, we believe 50% provides a conservative estimate of the needed replacement rate. However, this variable in the overall cost of the program can be selected by the City to provide their desired level of risk. A spreadsheet tool was developed and provided to the City to allow the City to test the effect of the percentage of no-till acres replaced and/or other program assumptios on total program costs and associated fee requirements.

Sediment credit fee structure. Although it would be most efficient for the initial project developer to pay the entire credit cost rather than to obtain and track recurring payments from two or more entities, an annual fee structure is recommended to meet the City's criteria that the program remain financial sustainable in perpetuity. It should be noted that the annual fee structure will add to the administrative burden to the City; however, since the City currently tracks all properties to administer the biannual water quality BMP inspection notice, the administrative responsibilities associated with the offsite program should not add excessively to that which is already undertaken. A spreadsheet tool has been provided to the City of Wichita to determine program costs and an annual fee to be charged to developers who participate in the program. Based on the cost to maintain sediment credits provided by offsite BMPs in perpetuity, we anticipate an annual cost of $30 to $40 per acre per year to participate in the offsite program. **To ensure the financial sustainability of the program, it is important that the City has the flexibility to adaptively manage program fee structures. It is recommended that the City review program fee structure periodically and adjust as necessary.**

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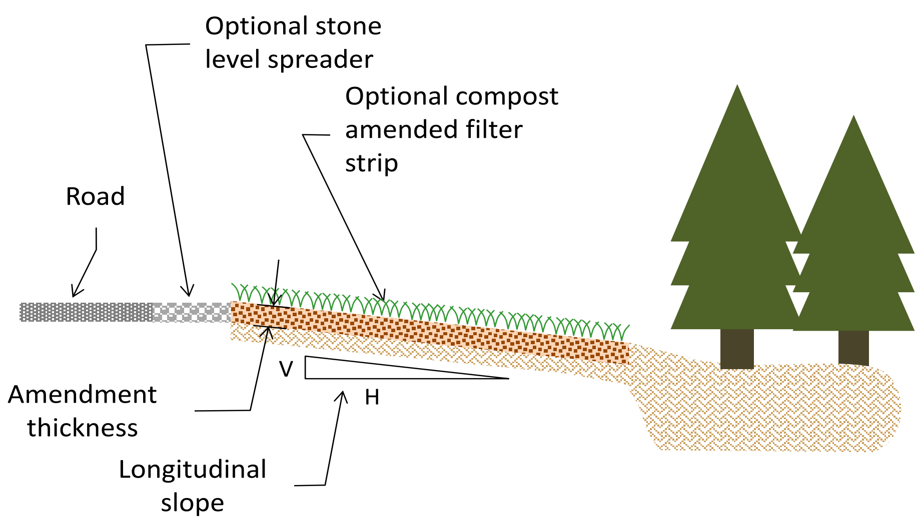
Appendix A

Design Assumptions and Associated Costs for Onsite (Urban) BMPs

Filter Strip Design Parameters		Design Guidance and Justification
Water Quality Flow (cfs)	0.50	The flow over the filter strip desired to meet the water quality design requirements.
Length (ft)	670	The length of the filter strip perpendicular to the flow; calculated based on filter strip length required to treat 1-ac impervious area (APWA-MARC, 2012)
Underlying Soil Design Infiltration Rate (in/hr)	0.5	Assumed based on predominant soil type in Wichita area.
Effective Amended Soil Depth (inches)	0	Depth of amended surface soil actively available for soil soaking and drying. Here, assumed no soil amendment added but that in-situ soils provide sufficient hydraulic conductivity.
Overland Flow Width (ft)	45	The width of the filter strip in the direction of the flow
Longitudinal Slope (ft/ft)	0.03	The average slope in the direction of flow, assumed based on typical slopes in area.
Manning's friction coefficient (n)	0.4	Describes hydraulic roughness of vegetation within filter strip
Water Quality Flow Depth (in)	0.21	Calculated based on water quality design flow and filter strip dimensions. Maintain value < 2/3 filter strip vegetation height to ensure sediment trapping efficiency.
Hydraulic Residence Time (min)	17.4	Calculated based on the water quality flow and the filter strip dimensions. Maintain value > 9 min.
Calculated Pervious Area (ft^2)	30,150	Estimated footprint area of vegetated filter strip.
Ratio of Pervious Area to Impervious Area	0.69	Calculated based on user inputs; fundamental indicator of volume reduction performance.



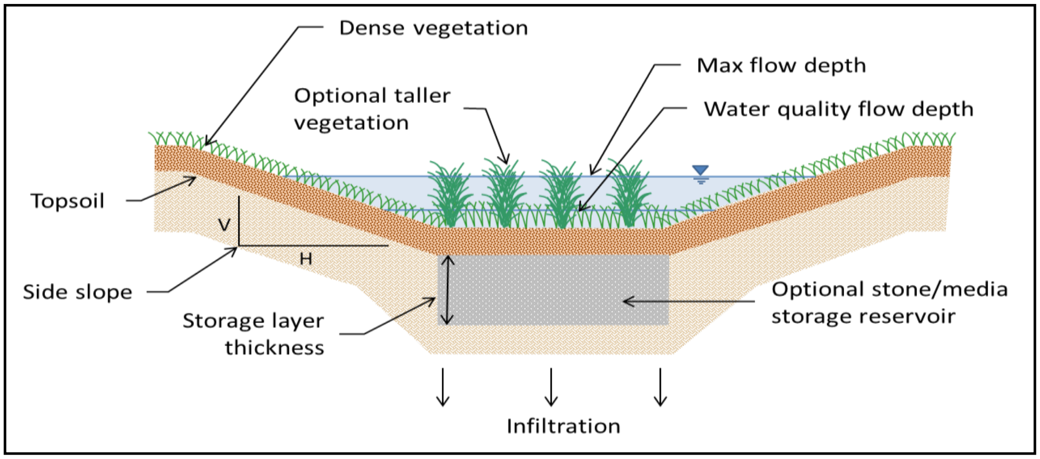
User-Entered Engineer's Estimate Costs	Unit	Cost	Quantity	Cost
Mobilization	LS	$558	0	$0
Clearing & Grubbing	SY	$1	3,350	$3,201
Excavation/Grading	CY	$18	0	$0
Haul/Dispose of Excavated Material	CY	$10	0	$0
Hydroseed (SF):	SF	$0	30,150	$2,379
Traffic Control	LF	$12	0	$0

Associated Capital Costs	Unit Cost	Quantity	Cost
Project Management	$554	1	$554
Engineering: Preliminary	$558	1	$558
Engineering: Final Design	$279	1	$279
Topographic Survey	$4,025	1	$4,025
Geotechnical	$2,350	1	$2,350
Landscape Design	$112	1	$112
Land Acquisition (site, easements, etc.)	$0	1	$0
Utility Relocation	$0	1	$0
Legal Services	$56	1	$56
Permitting & Construction Inspection	$56	1	$56
Sales Tax	$399	1	$399
Contingency (e.g., 20%)	$1,116	1	$1,116
Total Associated Capital Costs		**$8,950**	
Total Facility Cost		**$14,530**	

Life cycle results:

Estimated Capital Cost, $ (2013)	$14,530
Estimated NPV of Design Life Maintenance Costs, $ (2013)	$16,466
Estimated NPV of Design Life Whole Life Cycle Cost, $ (2013)	$30,996
Estimated Annualized Whole Life Cycle Cost, $/yr (2013)	$1,240
Annual TSS Load reduction (tons/yr; % removed)	0.41 tons/yr, 96% annual reduction
Whole Lifecycle cost per ton TSS removed	$3020

Vegetated Swale: Design and Cost Assumptions



Primary Swale Design Parameters		Guidance
Water Quality Design Flow (cfs)	0.45	The flow through the swale required to achieve the desired water quality performance
Bottom Length (ft)	100	Minimum acceptable length from APWA-MARC (2012) guidance selected
Effective Amended Soil Depth (inches)	6	As water quality swale, assumed 6-inch gravel storage layer.
Underlying Soil Design Infiltration Rate (in/hr)	0.5	Assumed based on predominant soil type in Wichita area.
Longitudinal Slope (ft/ft)	0.03	The average slope in the direction of flow. Assumed based on slopes typical in area.
Time of concentration (min)	5	Time of concentration from 1-acre impervious watershed
Manning's friction coefficient (n)	0.4	Describes hydraulic roughness of vegetation within swale
Horizontal/vertical side slope ratio (H:1V)	3	3 to 1 side slopes assumed as specified in APWA-MARC (2012)
Water Quality Flow Depth (in)	4	Maximum water quality design depth specified in APWA-MARC (2012)
Maximum Depth (ft)	2	Depth from the bottom of the swale up to the freeboard
Freeboard Depth (ft)	1	Neglected when estimating treatment volumes because overflow/bypass is assumed to begin when the water quality storage volume has been exhausted. However, it is included in cost calculations and volume loss calculations.
Bottom Width (ft)	3.99	Between recommended 2 to 8 ft (APWA-MARC, 2012)
Calculated Pervious Area (ft2)	599	Estimate footprint area for volume reduction calculations.
Ratio of Pervious Area to Impervious Area	0.01	Calculated based on user inputs; fundamental indicator of volume reduction performance.
Wetted Area (ft2)	1.66	Calculated based on previous inputs for water quality estimation only
Wetted Perimeter (ft)	6.1	
Hydraulic Radius (ft)	0.27	
Calculated Design Intensity (in/hr)	0.50	
Hydraulic Residence Time (min)	6	Calculated based on the water quality flow and the swale bottom length

Engineer's Estimate Costs	Unit	Unit cost	Quantity	Cost
Clearing & Grubbing	SY	$1	244	$244
Excavation/Grading	CY	$69	137	$9,450
Haul/Dispose of Excavated Material	CY	$10	41	$423
Overflow Structure (concrete or rock riprap)	CY	$125	7	$875
Hydroseed / Erosion Control:	SF	$0.1	244	$19
			Total Facility Base Cost	**$11,088**

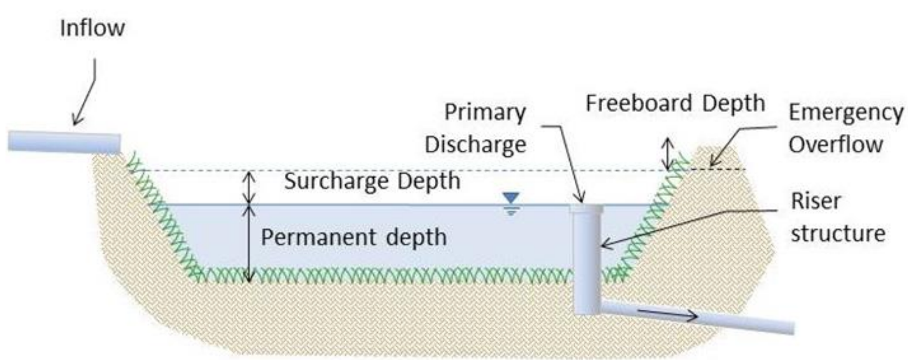
Associated Capital Costs	Unit cost	Quantity	Cost
Project Management	$554	1	$554
Engineering: Preliminary	$1,109	1	$1,109
Engineering: Final Design	$554	1	$554
Topographic Survey	$4,025	1	$4,025
Geotechnical	$2,350	1	$2,350
Landscape Design	$222	1	$222
Land Acquisition (site, easements, etc.) $/acre	$0	0.02	$0
Utility Relocation	$0	1	$0
Legal Services	$111	1	$111
Permitting & Construction Inspection	$111	1	$111
Sales Tax	$793	1	$793
Contingency (e.g., 20%)	$2,218	1	$2,218
		Total Associated Capital Costs	**$12,047**
		Total Facility Cost	**$23,135**

Life cycle results:

Estimated Capital Cost, $ (2013)	$25,358
Estimated NPV of Design Life Maintenance Costs, $ (2013)	$16,466
Estimated NPV of Design Life Whole Life Cycle Cost, $ (2013)	$41,825
Estimated Annualized Whole Life Cycle Cost, $/yr (2013)	$1,673
Annual TSS Load reduction (tons/yr; % removed)	0.185 tons/yr, 43% annual reduction
Whole Lifecycle cost per ton TSS removed	$8660

Extended Detention: Design and Cost Assumptions

Ext. Detention Design Parameters	Value	Guidance
Total Storage Volume (cu-ft)	4,000	Water quality storage volume from 1-ac impervious watershed
Surcharge Depth (ft)	1.00	Assumed depth from the permanent pool elevation up to the overflow elevation.
Permanent Pool Depth (ft)	4.00	Assumed height of outlet offset from the bottom of the pond.
Surcharge Volume Drawdown Time (hr)	12	Follows recommended drawdown time from APWA-MARC (2012)
Minimum Residence Time in the Permanent Pool (hours)	12	Follows recommended drawdown time from APWA-MARC (2012)
BMP Length/width ratio (L:1W)	2	The length-to-width ratio at mid-water quality design depth; dimension assumed.
Freeboard depth (ft)	1	The storage depth above the water quality volume; included in cost calculations
Horizontal/vertical side slope ratio (H:1V)	3	3:1 side slopes assumed
Calculated Surcharge Volume (ft3)	1,700	The extended detention portion of the water quality volume. Does not include freeboard above the spillway.
Calculated Permanent Pool Volume (ft3)	2,300	The wet pool portion of the water quality volume.
Permanent Pool Water Quality Flow (cfs)	0.053	The calculated water quality flow rate based on the target minimum residence time.
Approximate Total Footprint to Top of Freeboard (ft^2)	2,520	This footprint accounts for freeboard above ponding, assuming a rectangular shape; actual dimensions may vary.
Approximate Surcharge Surface Area (ft^2)	1,928	This footprint represents the surface area of the basin at the surcharge depth; assumes a rectangular shape.
Approximate Permanent Pool Surface Area (ft^2)	1,405	This footprint represents the surface area of the basin at the permanent pool depth; assumes a rectangular shape.
Permanent Pool Exchange Rate (hr)	48.00	The time required to completely exchange the permanent pool volume.
Complete Capture Settling (hr)	4.00	Estimated time required to settle a 20 micron particle in the permanent pool, following Stoke's Law.



Engineer's Estimate Costs	Unit	Cost/Unit	Quantity	Cost
Clearing & Grubbing	SY	$1	280	$280

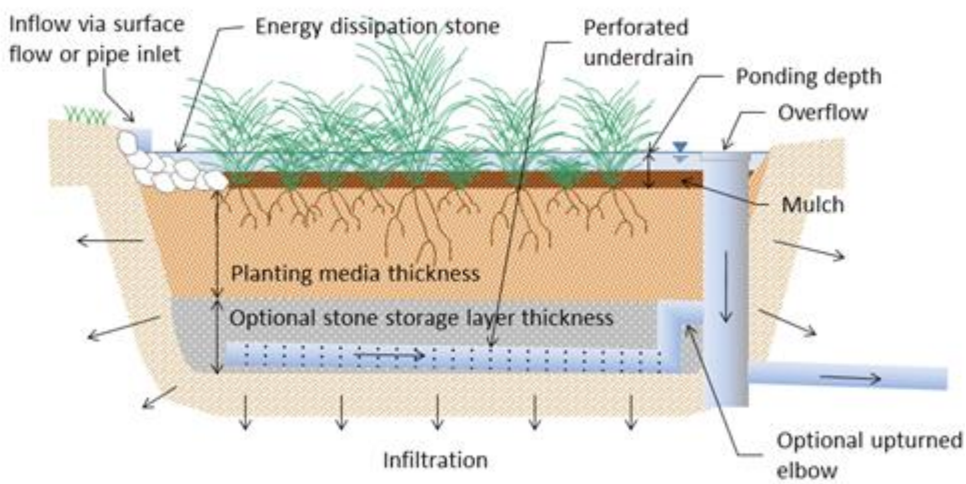
Excavation/Grading	BCY	$18	185	$3,358
Haul/Dispose of Excavated Material	CY	$10	90	$900
Inflow Structure(s)	LS	$2,200	1	$2,200
Energy Dissipation Apron	CY	$191	4	$707
Outflow Structure	LS	$2,200	1	$2,200
Overflow Structure (concrete or rock riprap)	CY	$125	7	$926
Impermeable Liner	SF	$2	1000	$2,200
Water's Edge Vegetation	EA	$25	45	$1,125
Wetlands Vegetation	EA	$100	0	$0
Site Landscaping (e.g., trees)	EA	$345	0	$0
Maintenance Access Ramp/Pad	CY	$191	4	$707
Hydroseed / Erosion Control:	SY	$1	76	$54
			Total Facility Base Cost	**$14,345**

Associated Capital Costs	Cost/unit	Quantity	Total Cost
Project Management	$758	1	$758
Engineering: Preliminary	$1,516	1	$1,516
Engineering: Final Design	$758	1	$758
Topographic Survey	$4,025	1	$4,025
Geotechnical	$2,350	1	$2,350
Landscape Design	$303	1	$303
Land Acquisition (site, easements, etc.)	$0	1	$0
Utility Relocation	$0	1	$0
Legal Services	$152	1	$152
Permitting & Construction Inspection	$152	1	$152
Sales Tax	$1,084	1	$1,084
Contingency (e.g., 20%)	$3,032	1	$3,032
		Total Associated Capital Costs	**$14,130**
		Total Facility Cost	**$29,291**

Life-Cycle Cost Analysis Results

Estimated Capital Cost, $ (2013)	**$28,058**
Estimated NPV of Design Life Maintenance Costs, $ (2013)	**$131,249**
Estimated NPV of Design Life Whole Life Cycle Cost, $ (2013)	**$159,307**
Estimated Annualized Whole Life Cycle Cost, $/yr (2013)	**$6,372.27**
Annual TSS Load reduction (tons/yr; % removed)	**0.3525 tons/yr, 82% annual reduction**
Whole Lifecycle cost per ton TSS removed	**$18,080**

Bioretention: Design and Cost Assumptions



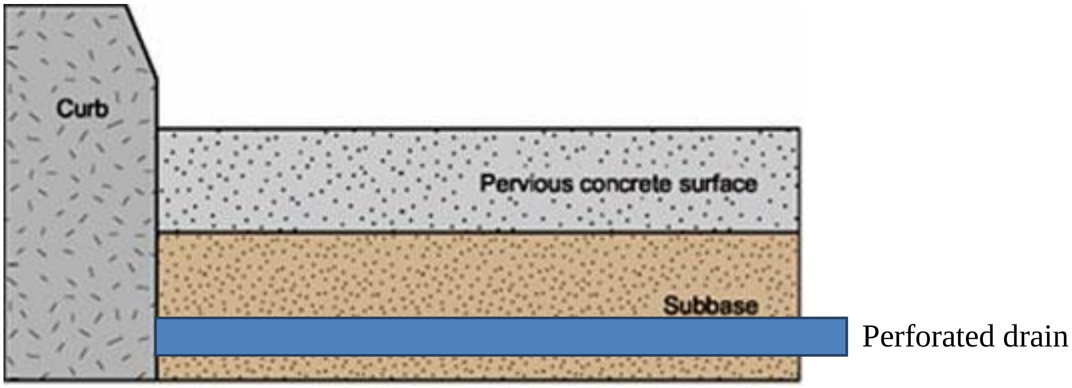
Primary Bioretention Design Parameters	Value	Guidance
Storage Volume (cu-ft)	3,600	Total storage volume provided by the bioretention as required to capture water quality volume from 1-ac impervious watershed
Underlying Soil Design Infiltration Rate (in/hr)	0.8	Assumed based on soils characteristic of the area
Underdrain Present?	no	Underlying soil infiltration rate assumed adequate
Ponding Depth (ft)	1	Maximum ponding depth recommended over the surface of the planting media (APWA-MARC, 2012)
Planting Media Thickness (ft)	2.5	Minimum planning media thickness (APWA-MARC, 2012)
Stone Reservoir Thickness (ft)	1	Typical stone reservoir thickness (APWA-MARC, 2012)
Planting Media Filtration Rate (in/hr)	2	Assumed long-term (and desirable) infiltration rate
Soil Freely Drained Storage (in/in)	0.2	Porosity typical of sandy soil planting media
Crop coefficient of Vegetation	1.25	Crop coefficient of native prairie grasses during peak growth; used in ET calculations
Stone Freely Drained Storage (in/in)	0.4	Typical porosity of gravel layer
BMP Length/width ratio (L:1W)	2	For example: For BMP that is 60 feet long by 20 feet wide, enter 3
Mulch depth above Planting Media Layer (ft)	0.25	Assumed 3 inch mulch thickness, typical of bioretention
Mulch porosity (in/in)	0.5	Included in water quality volume calculations
Freeboard depth (ft)	0.5	Assumed value; depth included in cost calculations.
Horizontal/vertical side slope ratio (H:1V)	4	4:1 is maximum slope specified in APWA-MARC (2012)
Approximate Total Footprint to Top of Freeboard, sq-ft	1,890	This footprint accounts for freeboard above ponding, assuming a rectangular shape; actual dimensions may vary.
Calculated Drawdown Time of Surface Ponding, hours	15	For Reference Purposes Only: For bioretention, a target of 3 to 24 hours is typically recommended.

Clearing & Grubbing	SY	$1	209	$200
Planting Media	CY	$43	139	$5,975
Gravel	CY	$27	60	$1,620
Mulch	CY	$71	15	$1,072
Slotted PVC Underdrain Pipe	LF	$8	0	$0
Excavation/Grading	CY	$18	332	$6,019
Haul/Dispose of Excavated Material	CY	$10	133	$1,370
Finish Grading (SY):	SY	$2	209	$415
Bioretention Vegetation (SF)	SF	$2	1,620	$3,667
Hydroseed (SF):	SF	$0	1,620	$128
Inflow Structure(s)	LS	$2,200	1	$2,200
Overflow Structure (concrete or rock riprap)	CY	$125	7	$875
			Total Facility Base Cost	**$23,542**

Project Management	$1,136	1	$1,177
Engineering: Preliminary	$2,273	1	$2,354
Engineering: Final Design	$1,136	1	$1,177
Topographic Survey	$568	1	$589
Geotechnical	$0	1	$0
Landscape Design	$455	1	$471
Land Acquisition (site, easements, etc.), $/ac	$0	0.04	$0
Utility Relocation	$0	1	$0
Legal Services	$227	1	$235
Permitting & Construction Inspection	$227	1	$235
Sales Tax	$1,625	1	$1,683
Contingency (e.g., 20%)	$4,546	1	$4,708
		Total Associated Capital Costs	**$12,630**
		Total Facility Cost	**$34,921**

Estimated Capital Cost, $ (2013)	**$36,162**
Estimated NPV of Design Life Maintenance Costs, $ (2013)	**$23,177**
Estimated NPV of Design Life Whole Life Cycle Cost, $ (2013)	**$59,349**
Estimated Annualized Whole Life Cycle Cost, $/yr (2013)	**$2,373.95**
Annual TSS Load reduction (tons/yr; % removed)	**0.3225 tons/yr, 77% annual reduction**
Whole Lifecycle cost per ton TSS removed	**$7240**

Permeable Pavement: Design and Cost Assumptions



Permeable Pavement Design Parameters	Value	Guidance
Storage Volume (cu-ft)	9,475	Storage volume provided by 12-in aggregate base layer and 6-in thick porous concrete across a 0.5-acre pervious pavement system. Depths follow APWA-MARC (2012)
Underlying Soil Design Infiltration Rate (in/hr)	0.8	Based on assumed infiltration of native soils underlying permeable pavement system.
Underdrain Present?	yes	Assume 4-in perforated pipe on 10-ft centers
Pervious pavement thickness (ft)	0.5	Minimum thickness suggested for pervious pavement (APWA-MARC, 2012)
Gravel base thickness (ft)	1	Minimum thickness suggested for subbase to provide adequate structural support (APWA-MARC, 2012)
Underdrain Discharge Elev. from bottom of stone reservoir (ft)	0.25	Follows minimum cover between perforated underdrain and bottom of pavement system (APWA-MARC, 2012)
Pervious pavement filtration rate (in/hr)	2	Reflect minimum long-term conditions expected for maintained pervious pavement systems
Permeable pavement porosity (in/in)	0.15	Reflects minimum recommended porosity
Pavement system Suction Storage (in/in)	0.05	Relatively little water is held in tension after free drainage by system of permeable pavement/gravel
Equivalent crop coefficient	0.7	Water demand by evaporation only, no transpiration and therefore crop coefficient < 1
Gravel base porosity (in/in)	0.36	Assumed porosity of gravel sub –layer (APWA-MARC, 2012)
BMP Length/width ratio (L:1W)	1	Assumes square orientation
Freeboard depth (ft)	0.5	Assumed equal to curb height
Approximate Total Footprint to Top of Freeboard, sq-ft	9,475	This footprint accounts for freeboard above ponding, assuming a rectangular shape; actual dimensions may vary.
Calculated Drawdown Time of Surface Ponding, hours	3	For Reference Purposes Only: For bioretention, a target of 3 to 24 hours is typically recommended.

Clearing & Grubbing	SY	$1	2240	$2,141
Pervious concrete	SF	$3	21780	$65,340
Gravel	CY	$27	806	$21,762
Slotted PVC Underdrain Pipe	LF	$4	1032	$4,128
Excavation/Grading	CY	$18	1210	$21,962
Haul/Dispose of Excavated Material	CY	$10	600	$6,180
Inflow Structure(s)	LS	$2,200	1	$2,200
Overflow Structure (concrete or rock riprap)	CY	$125	7	$875
			Total Facility Base Cost	**$191,505**

Project Management	$6,232	1	$6,232
Engineering: Preliminary	$12,464	1	$12,464
Engineering: Final Design	$6,232	1	$6,232
Topographic Survey	$3,116	1	$3,116
Geotechnical	$0	1	$0
Landscape Design	$2,493	0	$0
Land Acquisition (site, easements, etc.), $/ac	$0	0.5	$0
Utility Relocation	$0	1	$0
Legal Services	$1,246	1	$1,246
Permitting & Construction Inspection	$1,246	1	$1,246
Sales Tax	$8,912	1	$8,912
Contingency (e.g., 20%)	$24,698	1	$24,698
		Total Associated Capital Costs	**$64,375**
		Total Facility Cost	**$189,012**

Life Cycle Cost analysis results:

Estimated Capital Cost, $ (2013)	**$189,012**
Estimated NPV of Design Life Maintenance Costs, $ (2013)	**$25,835**
Estimated NPV of Design Life Whole Life Cycle Cost, $ (2013)	**$214,847**
Estimated Annualized Whole Life Cycle Cost, $/yr (2013)	**$8,593.88**
Annual TSS Load reduction (tons/yr; % removed)	**0.376 tons/yr, 88% annual reduction**
Whole Lifecycle cost per ton TSS removed	**$22800**

Hydrodynamic separator: Design and Cost Assumptions

The design of hydrodynamic separators is typically specified by the manufacture. For the purposes of this analysis, costs representative of a proprietary hydrodynamic separation device with a 1-acre impervious watershed were derived from costs compiled in the International Stormwater BMP database (bmpdatabase.org). Capital and recurring costs are summarized in the following table.

Hydrodynamic separator materials	EA	$15,000	1	$15,000
Excavation	CY	$18	5	$90
Installation (Labor)	LS	$7,500	1	$7,500
Engineering and Overhead	LS	$3,375	1	$3,375
Total Capital Costs				$25,965
Recurring Maintenance Costs				
Inspection, quarterly	EA	$250	4	$1,000
Sediment disposal	YR	$1,500	1	$1,500
Annual Maintenance Costs				$2,500

Life Cycle Cost analysis results:

Estimated Capital Cost, $ (2013)	**$25,965**
Estimated NPV of Design Life Maintenance Costs, $ (2013)	**$53,456**
Estimated NPV of Design Life Whole Life Cycle Cost, $ (2013)	**$79,421**
Estimated Annualized Whole Life Cycle Cost, $/yr (2013)	**$1,588**
Annual TSS Load reduction (tons/yr; % removed)*	**0.32 tons/yr; 50% removal**
Whole Lifecycle cost per ton TSS remove	**$9,928**

*Assumed sediment removal efficiency of 75% (BMP database, 2014; Wilson et al., 2009).

Riparian setback

As reviewed by Mankin et al. (2007), the majority of sediment removal within vegetative buffers tends to occur within the first 30-45 ft. Therefore, for the purposes of this assessment, a 45-foot buffer width on either side of the stream was assumed. A mean effluent concentration of 15 mg/l total suspended sediments was assumed following experimental data collected in North East Kansas (Mankin et al., 2007). Riparian buffers should also reduce in-stream channel erosion, but this contribution is yet to be quantified well and is therefore not included in this analysis. As a non-structural BMP, engineering and construction costs associated with riparian setbacks are assumed equal to $0. However, opportunity costs in terms of land ($30,000 and $90,000 per acre residential and commercial, respectively) and nominal maintenance costs (assumed $1,000 per acre per year) are considered. Resulting life cycle cost-benefit analysis results are summarized in the following table.

Life Cycle Cost analysis results per one acre stream buffer

Estimated Capital Cost, $ (2013)	**$0**	**$30,000**	**$90,000**
Estimated NPV of Design Life Maintenance Costs, $ (2013)	**$18,985**	**$18,985**	**$18,985**
Estimated NPV of Design Life Whole Life Cycle Cost, $ (2013)	**$18,985**	**$48,985**	**$108,985**
Estimated Annualized Whole Life Cycle Cost, $/yr (2013)	**$759**	**$1,959**	**$4,359**
Annual TSS Load reduction (tons/yr; % removed)*	**0.405 tons/yr; 95% removal**		
Whole Lifecycle cost per ton TSS removed	**$1860**	**$4800**	**$10760**

Consideration of large-scale development and incremental costs associated with onsite peak rate + stormwater quality management

The incremental costs associated with constructing and maintaining stormwater water retention basins for rate control only versus rate *and* water quality control were compared to provide insight to the financial incentive (or lack thereof) to developers of large properties to participate in an offsite BMP implementation program rather than make the necessary design adjustments to manage both stormwater rate and quality on site. Three of the most common options for meeting both stormwater quantity and quality requirements in Wichita are assessed. These options are discussed below, and estimated costs associated with each are summarized in Table A.2.

The first option is to design an extended wet detention basin in which the water quality volume is detained above the permanent pond pool along with required flood control volume. This water quality volume is discharged over 40 hours (APWA-MARC, 2012). This water quality volume can be calculated using the so-called Simple Method proposed by Claytor and Schueler (1996):

$$WQ_v = P(R_v)$$

where WQ_v is the water quality volume (in inches), P is the water quality rainfall event (in inches) and R_v is the volumetric runoff coefficient equal to 0.05 + 0.009* (% impervious area). Assuming impervious surface coverage of 40% (typical of medium density residential) that is predominantly directly connected and a water quality rainfall event of 1.2 inches (the standard for the City of Wichita), the WQ_v to be captured and discharged over 40 hours is 0.49 inches. Assuming a 40-acre development, the volume of runoff to be captured for water quality treatment is 1.6 acre feet. For the purposes of rate control requirements, Table A.1 below provides an example of pre- and post-development conditions for the same 40-acre, 40% impervious development.

Table A.1. Pre and post development hydrologic design calculations.

			Pre-	Post-	Pre-	Post-	**Pre-**	**Post-**	**Pre-**	**Post-**
Design Storm	Precip Depth (in)	Area (ac)	Rational coeff C[a]		intensity (in/hr)[b]		**Peak discharge[c] (cfs)**		**Volume[d] (ac-ft)**	
2-yr, 24-hr	3.3	40	0.2	0.6	2.48	4.3	20	103	0.0	4.2
5-yr, 24-hr	4.5	40	0.2	0.6	3	5.17	24	124	0.3	6.3
10-yr, 24-hr	5.2	40	0.2	0.6	3.42	5.88	27	141	0.8	8.3
25-yr, 24-hr	6.1	40	0.22	0.66	4	6.84	35	181	1.8	11.3
100-yr, 24-hr	7.8	40	0.25	0.75	4.85	8.28	49	248	4.1	16.7

[a]Rational coefficient C selected based on assumption of pasture in good condition for predevelopment conditions and medium intensity residential/commercial post-development conditions.
[b]precipitation intensity determined based on time of concentration assumed for predevelopment (30 min) and post-development (10 min) conditions.
[c]Peak discharge calculated by rational equation (Q_p = CiA)
[d]Runoff volume calculated using SCS curve number method, assuming a curve number of 40 for predevelopment and 75 for post-development.

Per the City's requirement to maintain the peak flow associated with the 2-year through 100-year design storm, an initial estimate of the required pond volume above the permanent pool can be taken as the difference in the pre and post-development runoff volume for the 100-year event (12.6 ac-ft). This volume substantially exceeds the calculated water quality volume for the same development area (1.6 ac-ft), indicating that the water quality volume will be accounted for in the volume required to provide peak rate control. The extended detention requirement associated with the water quality volume should be accommodated through an outlet control structure with staged orifices. The cost of such a structure is nominal relative to the total cost of an extended wet detention basin; thus, there is little financial incentive driving participation in an offsite program for developers who prefer to use extended wet detention for peak rate control, through which water quality could be met onsite for nominal additional cost.

A second option is to design a dry detention basin for peak rate control and insert a hydrodynamic separator into the detention basin outlet to receive credit for stormwater quality control. Based on the preceding cost analysis, hydrodynamic separators cost approximately $16,000 per ton sediment removed assuming urban sediment loads, which is significantly more than total costs projected for participation in an offsite program (Table 9). Therefore, those developers who prefer to meet both rate and quality control requirements through retention and hydrodynamic separators are likely to save money by participating in an offsite program.

A third option would be to design a dry extended detention basin to meet peak rate requirements and participate in an offsite program rather than constructing an extended wet retention basin to achieve both peak rate and water quality requirements on site. For the example of a 40-acre development, the marginal cost between a detention basin for peak control only and an extended wet detention basin is about $100,000. Projected costs to participate in an offsite program are likely to be substantially less than $100,000; given the sediment credit payment rates projected in Section 3.2.4, we expect a 40-acre development would incur a use fee of about $5,200 to participate in an offsite program. Thus, there is likely to be a financial incentive to participate in an offsite BMP program for developers who choose to manage peak flows onsite with (dry) detention.

Table A.2. Estimated costs for peak rate and water quality management for various offsite and/or onsite stormwater BMPs.

Option	Net present value life cycle costs	Annualized cost per ton sediment removed
#1: extended wet retention for rate control *and* water quality	**$738,648**	$5,170
#2: detention for rate control with hydrodynamic separator for water quality	**$656,903** ($605,869 basin + $51,034 hydrodynamic separator)	$6,900
#3: detention for rate control and participation in offsite program	**$611,069** ($605,869 basin + $5,200[a] offsite BMP use charge[a])	$940[b]

[a]Assumes use charge of $130 per acre developed to participate in offsite BMP program.

[b]Includes cost of onsite rate control and offsite sediment retention. For offsite sediment retention, no-till is assumed as offsite BMP at a 2:1 credit ratio. The offsite BMP use charge purchases 26 tons of sediment reduction credits per year.

Appendix B

Design Assumptions and Associated Costs for Offsite (Rural) BMPs

General Data For Vegetative Filter Strip

Discount Rate	**3.50%**	
Cropland Rental Rate - not CCRP rental rate	**$90.50**	per acre / year
Annual Cropland Rental Growth Rate	**3.00%**	
Total Annual Costs	**$6.67**	per acre / year
Inflation Rate of Annual Costs	**4.00%**	

Project Length (feet)	**660**
Project Width (feet)	**66**
Acres (length x width/43,560)	**1.00**
Length of analysis (years)	**25**
Cropland Property Tax ($/acre)	**$5.00**
Tame Grass Property Tax ($/acre)	**$5.00**

COSTS

Total one-time	**$205.44**
Total annual	**$6.67**

PAYMENTS RECEIVED

Total one-time	**$0.00**
Total annual	**$0.00**

Net Present Value Table: Vegetative Filter Strip (per acre)

Year	One Time Costs	Annual Costs	One Time Payments	Annual Payments	Net Property Tax Impact
0	$205.44	$0.00	$0.00	$0.00	$0.00
1	$0.00	$6.67	$0.00	$0.00	$0.00
2	$0.00	$6.94	$0.00	$0.00	$0.00
3	$0.00	$7.21	$0.00	$0.00	$0.00
4	$0.00	$7.50	$0.00	$0.00	$0.00
5	$0.00	$7.80	$0.00	$0.00	$0.00
6	$0.00	$8.12	$0.00	$0.00	$0.00
7	$0.00	$8.44	$0.00	$0.00	$0.00
8	$0.00	$8.78	$0.00	$0.00	$0.00
9	$0.00	$9.13	$0.00	$0.00	$0.00
10	$0.00	$9.49	$0.00	$0.00	$0.00
11	$0.00	$9.87	$0.00	$0.00	$0.00
12	$0.00	$10.27	$0.00	$0.00	$0.00
13	$0.00	$10.68	$0.00	$0.00	$0.00
14	$0.00	$11.11	$0.00	$0.00	$0.00
15	$0.00	$11.55	$0.00	$0.00	$0.00
16	$0.00	$12.01	$0.00	$0.00	$0.00
17	$0.00	$12.49	$0.00	$0.00	$0.00

NPV Table: Cropland Rent (per acre)

Year	Rent
0	$0.00
1	$90.50
2	$93.22
3	$96.01
4	$98.89
5	$101.86
6	$104.91
7	$108.06
8	$111.30
9	$114.64
10	$118.08
11	$121.62
12	$125.27
13	$129.03
14	$132.90
15	$136.89
16	$141.00
17	$145.23

18	$0.00	$12.99	$0.00	$0.00	$0.00
19	$0.00	$13.51	$0.00	$0.00	$0.00
20	$0.00	$14.05	$0.00	$0.00	$0.00
21	$0.00	$14.61	$0.00	$0.00	$0.00
22	$0.00	$15.20	$0.00	$0.00	$0.00
23	$0.00	$15.81	$0.00	$0.00	$0.00
24	$0.00	$16.44	$0.00	$0.00	$0.00
25	$0.00	$17.10	$0.00	$0.00	$0.00
Sum totals	$205.44	$277.78	$0.00	$0.00	$0.00
Present Value	$205.44	$170.81	$0.00	$0.00	$0.00
Net Present Value	**$483.22**				
Annualized Value	**$29.32**				

18	$149.58
19	$154.07
20	$158.69
21	$163.45
22	$168.36
23	$173.41
24	$178.61
25	$183.97
Sum totals	$3,299.56
Present Value	$2,063.84
Net Present Value	**$2,063.84**
Annualized Value	**$125.22**

Total cost equals annualized cost of filter strip plus annualized rent foregone: **$154.54** **per acre**

Assumed every 1 acre of filter strip treats 10 acres cropland (Smith and Williams, 2008). Assume median cropland runoff concentrations is 4,400 mg/l (Mankin et al., 2007), resulting in annual load of 4.5 tons sediment per acre per year, or 112 tons per 25 acres cropland . Documented sediment removal efficiencies of agricultural filter strips range from 70 to 95%. Assuming average performance of 72% (Smith, 2011), annual sediment removal is **32 tons sediment per acre filter strip area per yea**r. Therefore, the annual cost is:

$4.83 **per ton sediment removed per acre filter strip per year**

General Data For Streambank Stabilization

Discount Rate	3.50%	
Cropland Rental Rate - not CCRP rental rate	$90.50	per acre / year
Annual Cropland Rental Growth Rate	3.00%	
Total Annual Costs	$6.67	per acre / year
Inflation Rate of Annual Costs	4.00%	

Project Length (feet)	348
Project Width (feet)	125
Acres (length x width/43,560)	1.00
Length of analysis (years)	25
Cropland Property Tax ($/acre)	$5.00
Tame Grass Property Tax ($/acre)	$5.00

COSTS		PAYMENTS RECEIVED	
Total one-time	$ 36,966.8	Total one-time	$0.00
Total annual	$6.67	Total annual	$0.00

[c]Williams et al., 2004 (adjusted for inflation)

Estimated Capital Costs[c]		
Enginering & design	$	8,530.80
Equipment costs	$	14,652.00
Labor costs	$	1,148.00
Material costs	$	12,636.00
Total	$	36,966.80
Total, $/ft	$	106.23

Net Present Value Table: Streambank Stabilization (per acre)

Year	One Time Costs	Annual Costs	One Time Payments	Annual Payments	Net Property Tax Impact
0	$36,966.80	$0.00	$0.00	$0.00	$0.00
1	$0.00	$6.67	$0.00	$0.00	$0.00
2	$0.00	$6.94	$0.00	$0.00	$0.00
3	$0.00	$7.21	$0.00	$0.00	$0.00
4	$0.00	$7.50	$0.00	$0.00	$0.00
5	$0.00	$7.80	$0.00	$0.00	$0.00
6	$0.00	$8.12	$0.00	$0.00	$0.00
7	$0.00	$8.44	$0.00	$0.00	$0.00
8	$0.00	$8.78	$0.00	$0.00	$0.00
9	$0.00	$9.13	$0.00	$0.00	$0.00
10	$0.00	$9.49	$0.00	$0.00	$0.00
11	$0.00	$9.87	$0.00	$0.00	$0.00
12	$0.00	$10.27	$0.00	$0.00	$0.00
13	$0.00	$10.68	$0.00	$0.00	$0.00
14	$0.00	$11.11	$0.00	$0.00	$0.00
15	$0.00	$11.55	$0.00	$0.00	$0.00

NPV Table: Cropland Rent (per acre)

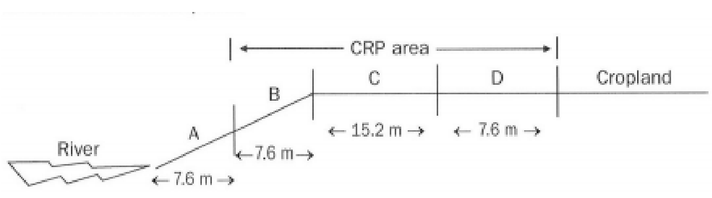
Year	Rent
0	$0.00
1	$90.50
2	$93.22
3	$96.01
4	$98.89
5	$101.86
6	$104.91
7	$108.06
8	$111.30
9	$114.64
10	$118.08
11	$121.62
12	$125.27
13	$129.03
14	$132.90
15	$136.89

16	$0.00	$12.01	$0.00	$0.00	$0.00		16	$141.00
17	$0.00	$12.49	$0.00	$0.00	$0.00		17	$145.23
18	$0.00	$12.99	$0.00	$0.00	$0.00		18	$149.58
19	$0.00	$13.51	$0.00	$0.00	$0.00		19	$154.07
20	$0.00	$14.05	$0.00	$0.00	$0.00		20	$158.69
21	$0.00	$14.61	$0.00	$0.00	$0.00		21	$163.45
22	$0.00	$15.20	$0.00	$0.00	$0.00		22	$168.36
23	$0.00	$15.81	$0.00	$0.00	$0.00		23	$173.41
24	$0.00	$16.44	$0.00	$0.00	$0.00		24	$178.61
25	$0.00	$17.10	$0.00	$0.00	$0.00		25	$183.97
Sum totals	$36,966.80	$277.78	$0.00	$0.00	$0.00		Sum totals	$3,299.56
Present Value	$205.44	$170.81	$0.00	$0.00	$0.00		Present Value	$2,063.84
Net Present Value	**$37,244.58**						**Net Present Value**	**$2,063.84**
Annualized Value	**$2,259.78**						**Annualized Value**	**$125.22**

Total cost equals annualized cost of filter strip plus annualized rent foregone: **$2,385** **per acre**

Annual streambank erosion rates as estimated along the Little Arkansas River in a study supported by the Little Ark WRAPS program (Hermes, 2012) were utilized (2.8 tons sediment per linear foot per year). Sediment reduction efficiency of stabilization projects was assumed equal to 95% based on sites monitored by Williams et al (2004). Assuming a linear length of 348 ft, total sediment reductions of **925 tons per year** are expected per acre streambank stabilization projects.

$2.58 **per ton sediment removed per year by 1 acre (348 linear ft) streambank stabilization project**



A. 7.6 meters on average of willow and cottonwood trees using a 1.2 meter spacing for willows and 1.8 meter spacing for cottonwood.

B. 7.6 meters of cottonwoods, silver maples, and/or sycamore trees using an 2.4 meter spacing.

C. 15.2 meters of trees and shrubs including one row each of green ash, black walnut, and burr oak trees using a 3.0 x 3.7 meter spacing and one row each of choke cherry, fragrant sumac, and American plum shrubs using a 1.8 x 1.8 meter spacing.

D. 7.6 meters of native grass mixtures of Big Bluestem, Indiangrass, Switchgrass, Sideoats Gramma, and Western Wheatgrass.

Hermes, K. 2012. Lower Arkansas basin streambank erosion assessment. ArcGIS comparison study: 1991 vs 2010 aerial photography. Kansas Water Office, Topeka, KS.

General Data For Permanent Vegetation

Discount Rate	**3.50%**	
Cropland Rental Rate - not CCRP rental rate	**$90.50**	per acre / year
Annual Cropland Rental Growth Rate	**3.00%**	
Total Annual Costs	**$6.67**	per acre / year
Inflation Rate of Annual Costs	**4.00%**	

Project Length (feet)	**660**
Project Width (feet)	**66**
Acres (length x width/43,560)	**1.00**
Length of analysis (years)	**25**
Cropland Property Tax ($/acre)	**$5.00**
Tame Grass Property Tax ($/acre)	**$5.00**

COSTS		**PAYMENTS RECEIVED**	
Total one-time	**$205.44**	Total one-time	**$0.00**
Total annual	**$6.67**	Total annual	**$0.00**

Net Present Value Table: Permanent Vegetation (per acre)

Year	One Time Costs	Annual Costs	One Time Payments	Annual Payments	Net Property Tax Impact
0	$101.42	$0.00	$0.00	$0.00	$0.00
1	$0.00	$6.67	$0.00	$0.00	$0.00
2	$0.00	$6.94	$0.00	$0.00	$0.00
3	$0.00	$7.21	$0.00	$0.00	$0.00
4	$0.00	$7.50	$0.00	$0.00	$0.00
5	$0.00	$7.80	$0.00	$0.00	$0.00
6	$0.00	$8.12	$0.00	$0.00	$0.00
7	$0.00	$8.44	$0.00	$0.00	$0.00
8	$0.00	$8.78	$0.00	$0.00	$0.00
9	$0.00	$9.13	$0.00	$0.00	$0.00
10	$0.00	$9.49	$0.00	$0.00	$0.00
11	$0.00	$9.87	$0.00	$0.00	$0.00
12	$0.00	$10.27	$0.00	$0.00	$0.00
13	$0.00	$10.68	$0.00	$0.00	$0.00
14	$0.00	$11.11	$0.00	$0.00	$0.00
15	$0.00	$11.55	$0.00	$0.00	$0.00

NPV Table: Cropland Rent (per acre)

Year	Rent
0	$0.00
1	$90.50
2	$93.22
3	$96.01
4	$98.89
5	$101.86
6	$104.91
7	$108.06
8	$111.30
9	$114.64
10	$118.08
11	$121.62
12	$125.27
13	$129.03
14	$132.90
15	$136.89

16	$0.00	$12.01	$0.00	$0.00	$0.00
17	$0.00	$12.49	$0.00	$0.00	$0.00
18	$0.00	$12.99	$0.00	$0.00	$0.00
19	$0.00	$13.51	$0.00	$0.00	$0.00
20	$0.00	$14.05	$0.00	$0.00	$0.00
21	$0.00	$14.61	$0.00	$0.00	$0.00
22	$0.00	$15.20	$0.00	$0.00	$0.00
23	$0.00	$15.81	$0.00	$0.00	$0.00
24	$0.00	$16.44	$0.00	$0.00	$0.00
25	$0.00	$17.10	$0.00	$0.00	$0.00
Sum totals	$101.42	$277.78	$0.00	$0.00	$0.00
Present Value	$101.42	$170.81	$0.00	$0.00	$0.00
Net Present Value	**$379.20**				
Annualized Value	**$23.01**				

16	$141.00
17	$145.23
18	$149.58
19	$154.07
20	$158.69
21	$163.45
22	$168.36
23	$173.41
24	$178.61
25	$183.97
Sum totals	$3,299.56
Present Value	$2,063.84
Net Present Value	**$2,063.84**
Annualized Value	**$125.22**

Total cost equals annualized cost of permanent vegetation plus annualized rent foregone: **$148.2** **per acre**

Converting 1 acre of cultivated land to permanent vegetation is assumed to reduce sediment loading by 94%, as based on modeling studies by Smith (2011) and Mankin et al. (2013). Assuming annual sediment load of 4.5 tons per acre cropland per year, annual sediment reductions achieved by converting to permanent vegetation are estimated to be **4.2 tons per year per acre**. Based on the lifecycle costs outlined above, the annual cost per ton sediment removed is:

$35.29 **per ton sediment removed per acre permanent vegetation restored per year**

General Data For Wetland Restoration

Discount Rate	**3.50%**	
Cropland Rental Rate - not CCRP rental rate	**$90.50**	per acre / year
Annual Cropland Rental Growth Rate	**3.00%**	
Total Annual Costs	**$6.67**	per acre / year
Inflation Rate of Annual Costs	**4.00%**	

Project Length (feet)	**660**
Project Width (feet)	**66**
Acres (length x width/43,560)	**1.00**
Length of analysis (years)	**25**
Cropland Property Tax ($/acre)	**$5.00**
Tame Grass Property Tax ($/acre)	**$5.00**

COSTS		PAYMENTS RECEIVED	
Total one-time	**$1,000.00**	Total one-time	**$0.00**
Total annual	**$6.67**	Total annual	**$0.00**

Net Present Value Table: Wetland Restoration (per acre)

Year	One Time Costs	Annual Costs	One Time Payments	Annual Payments	Net Property Tax Impact
0	$1,000.00	$0.00	$0.00	$0.00	$0.00
1	$0.00	$6.67	$0.00	$0.00	$0.00
2	$0.00	$6.94	$0.00	$0.00	$0.00
3	$0.00	$7.21	$0.00	$0.00	$0.00
4	$0.00	$7.50	$0.00	$0.00	$0.00
5	$0.00	$7.80	$0.00	$0.00	$0.00
6	$0.00	$8.12	$0.00	$0.00	$0.00
7	$0.00	$8.44	$0.00	$0.00	$0.00
8	$0.00	$8.78	$0.00	$0.00	$0.00
9	$0.00	$9.13	$0.00	$0.00	$0.00
10	$0.00	$9.49	$0.00	$0.00	$0.00
11	$0.00	$9.87	$0.00	$0.00	$0.00
12	$0.00	$10.27	$0.00	$0.00	$0.00
13	$0.00	$10.68	$0.00	$0.00	$0.00
14	$0.00	$11.11	$0.00	$0.00	$0.00
15	$0.00	$11.55	$0.00	$0.00	$0.00
16	$0.00	$12.01	$0.00	$0.00	$0.00
17	$0.00	$12.49	$0.00	$0.00	$0.00

NPV Table: Cropland Rent (per acre)

Year	Rent
0	$0.00
1	$90.50
2	$93.22
3	$96.01
4	$98.89
5	$101.86
6	$104.91
7	$108.06
8	$111.30
9	$114.64
10	$118.08
11	$121.62
12	$125.27
13	$129.03
14	$132.90
15	$136.89
16	$141.00
17	$145.23

18	$0.00	$12.99	$0.00	$0.00	$0.00
19	$0.00	$13.51	$0.00	$0.00	$0.00
20	$0.00	$14.05	$0.00	$0.00	$0.00
21	$0.00	$14.61	$0.00	$0.00	$0.00
22	$0.00	$15.20	$0.00	$0.00	$0.00
23	$0.00	$15.81	$0.00	$0.00	$0.00
24	$0.00	$16.44	$0.00	$0.00	$0.00
25	$0.00	$17.10	$0.00	$0.00	$0.00
Sum totals	$1,000.00	$277.78	$0.00	$0.00	$0.00
Present Value	$1,000.00	$170.81	$0.00	$0.00	$0.00
Net Present Value	**$1,277.78**				
Annualized Value	**$77.53**				

18	$149.58
19	$154.07
20	$158.69
21	$163.45
22	$168.36
23	$173.41
24	$178.61
25	$183.97
Sum totals	$3,299.56
Present Value	$2,063.84
Net Present Value	**$2,063.84**
Annualized Value	**$125.22**

Total cost equals annualized cost of wetland restoration plus annualized rent foregone: **$202.75** **per acre**

Re-establishing wetlands on previously drained cropland is expected to result in annual sediment reductions of **17 tons**, under the following assumptions: (1) area of restored wetland to directly drained cropland is 1:5 and (2) sediment reduction by the restored wetland is 75%. Accounting for foregone rent due to re-dedication of cropland to wetland, the annual cost of wetland restoration, in terms of sediment removed is:

$11.93 **per ton sediment per year per acre wetland restored**

General Data For Terrace-waterway

Discount Rate	**3.50%**	
Cropland Rental Rate - not CCRP rental rate	**$90.50**	per acre / year
Annual Cropland Rental Growth Rate	**3.00%**	
Total Annual Costs	**$6.67**	per acre / year
Inflation Rate of Annual Costs	**4.00%**	

Project Length (feet)	**660**
Project Width (feet)	**66**
Acres (length x width/43,560)	**1.00**
Length of analysis (years)	**25**
Cropland Property Tax ($/acre)	**$5.00**
Tame Grass Property Tax ($/acre)	**$5.00**

COSTS			PAYMENTS RECEIVED	
Total one-time	**$30.00**	[a]	Total one-time	**$0.00**
Total annual	**$13.60**	[a]	Total annual	**$0.00**

[a]Devlin et al., 2003

Net Present Value Table: Terrace-waterway (per acre)

Year	One Time Costs	Annual Costs	One Time Payments	Annual Payments	Net Property Tax Impact
0	$30.00	$0.00	$0.00	$0.00	$0.00
1	$0.00	$13.60	$0.00	$0.00	$0.00
2	$0.00	$14.14	$0.00	$0.00	$0.00
3	$0.00	$14.71	$0.00	$0.00	$0.00
4	$0.00	$15.30	$0.00	$0.00	$0.00
5	$0.00	$15.91	$0.00	$0.00	$0.00
6	$0.00	$16.55	$0.00	$0.00	$0.00
7	$0.00	$17.21	$0.00	$0.00	$0.00
8	$0.00	$17.90	$0.00	$0.00	$0.00
9	$0.00	$18.61	$0.00	$0.00	$0.00
10	$0.00	$19.36	$0.00	$0.00	$0.00
11	$0.00	$20.13	$0.00	$0.00	$0.00
12	$0.00	$20.94	$0.00	$0.00	$0.00
13	$0.00	$21.77	$0.00	$0.00	$0.00
14	$0.00	$22.64	$0.00	$0.00	$0.00
15	$0.00	$23.55	$0.00	$0.00	$0.00
16	$0.00	$24.49	$0.00	$0.00	$0.00
17	$0.00	$25.47	$0.00	$0.00	$0.00

NPV Table: Cropland Rent (per acre)

Year	Rent
0	$0.00
1	$90.50
2	$93.22
3	$96.01
4	$98.89
5	$101.86
6	$104.91
7	$108.06
8	$111.30
9	$114.64
10	$118.08
11	$121.62
12	$125.27
13	$129.03
14	$132.90
15	$136.89
16	$141.00
17	$145.23

18	$0.00	$26.49	$0.00	$0.00	$0.00
19	$0.00	$27.55	$0.00	$0.00	$0.00
20	$0.00	$28.65	$0.00	$0.00	$0.00
21	$0.00	$29.80	$0.00	$0.00	$0.00
22	$0.00	$30.99	$0.00	$0.00	$0.00
23	$0.00	$32.23	$0.00	$0.00	$0.00
24	$0.00	$33.52	$0.00	$0.00	$0.00
25	$0.00	$34.86	$0.00	$0.00	$0.00
Sum totals	$30.00	$566.38	$0.00	$0.00	$0.00
Present Value	$30.00	$348.27	$0.00	$0.00	$0.00
Net Present Value	**$596.38**				
Annualized Value	**$36.19**				

18	$149.58
19	$154.07
20	$158.69
21	$163.45
22	$168.36
23	$173.41
24	$178.61
25	$183.97
Sum totals	$3,299.56
Present Value	$2,063.84
Net Present Value	**$2,063.84**
Annualized Value	**$125.22**

Total cost equals annualized cost of terrace-waterway system plus annualized rent foregone: **$161.41** **per acre**

Terrace-grass water way systems are assumed to reduce edge-of-field sediment concentrations from cropland by 40% (Zhou et al., 2009). Assuming a baseline sediment loading of 4.5 tons sediment per year and that 10 acres of cropland are treater per 1 acre terrace-waterway system, implementation of terrace-grass waterway system is expected to reduce edge-of-field sediment from 45 tons to 23 tons, thereby resulting in total sediment removal of **18 tons sediment per year**.

$8.97 **per ton sediment removed per acre terrace-waterway system**

General Data For Riparian buffer (assumes re-establish with trees)

Discount Rate	**3.50%**	
Cropland Rental Rate - not CCRP rental rate	**$90.50**	per acre / year
Annual Cropland Rental Growth Rate	**3.00%**	
Total Annual Costs	**$6.67**	per acre / year
Inflation Rate of Annual Costs	**4.00%**	

Project Length (feet)	**660**
Project Width (feet)	**66**
Acres (length x width/43,560)	**1.00**
Length of analysis (years)	**25**
Cropland Property Tax ($/acre)	**$5.00**
Tame Grass Property Tax ($/acre)	**$5.00**

COSTS			**PAYMENTS RECEIVED**	
Total one-time	**$585.00**	[b]	Total one-time	**$0.00**
Total annual	**$0.00**		Total annual	**$0.00**

[b]Williams et al. (2004)

Net Present Value Table: Riparian buffer (per acre)

Year	One Time Costs	Annual Costs	One Time Payments	Annual Payments	Net Property Tax Impact
0	$585.00	$0.00	$0.00	$0.00	$0.00
1	$0.00	$0.00	$0.00	$0.00	$0.00
2	$0.00	$0.00	$0.00	$0.00	$0.00
3	$0.00	$0.00	$0.00	$0.00	$0.00
4	$0.00	$0.00	$0.00	$0.00	$0.00
5	$0.00	$0.00	$0.00	$0.00	$0.00
6	$0.00	$0.00	$0.00	$0.00	$0.00
7	$0.00	$0.00	$0.00	$0.00	$0.00
8	$0.00	$0.00	$0.00	$0.00	$0.00
9	$0.00	$0.00	$0.00	$0.00	$0.00
10	$0.00	$0.00	$0.00	$0.00	$0.00
11	$0.00	$0.00	$0.00	$0.00	$0.00
12	$0.00	$0.00	$0.00	$0.00	$0.00
13	$0.00	$0.00	$0.00	$0.00	$0.00
14	$0.00	$0.00	$0.00	$0.00	$0.00
15	$0.00	$0.00	$0.00	$0.00	$0.00
16	$0.00	$0.00	$0.00	$0.00	$0.00

NPV Table: Cropland Rent (per acre)

Year	Rent
0	$0.00
1	$90.50
2	$93.22
3	$96.01
4	$98.89
5	$101.86
6	$104.91
7	$108.06
8	$111.30
9	$114.64
10	$118.08
11	$121.62
12	$125.27
13	$129.03
14	$132.90
15	$136.89
16	$141.00

17	$0.00	$0.00	$0.00	$0.00	$0.00
18	$0.00	$0.00	$0.00	$0.00	$0.00
19	$0.00	$0.00	$0.00	$0.00	$0.00
20	$0.00	$0.00	$0.00	$0.00	$0.00
21	$0.00	$0.00	$0.00	$0.00	$0.00
22	$0.00	$0.00	$0.00	$0.00	$0.00
23	$0.00	$0.00	$0.00	$0.00	$0.00
24	$0.00	$0.00	$0.00	$0.00	$0.00
25	$0.00	$0.00	$0.00	$0.00	$0.00
Sum totals	$585.00	$0.00	$0.00	$0.00	$0.00
Present Value	$585.00	$0.00	$0.00	$0.00	$0.00
Net Present Value	**$585.00**				
Annualized Value	**$35.49**				

17	$145.23
18	$149.58
19	$154.07
20	$158.69
21	$163.45
22	$168.36
23	$173.41
24	$178.61
25	$183.97
Sum totals	$3,299.56
Present Value	$2,063.84
Net Present Value	**$2,063.84**
Annualized Value	**$125.22**

Total cost equals annualized cost of riparian buffer establishment plus annualized rent foregone: **$160.72 per acre**

The ratio of cropland:riparian buffer area is assumed to be 5, therefore, 5 acres of cropland are drained per 1 acre riparian buffer. Following removal rates reported by Mankin et al. (2007) and Zhou et al (2009), riparian buffers are expected to have a 50% sediment removal efficiency. These assumptions result in an annual sediment reduction of about **11 tons per acre riparian buffer per year**. Therefore, the annual cost is:

$14.61 per ton sediment removed per acre riparian buffer per year*

*note that this does not consider potential reductions in erosion rates from the stream channel.

General Data For No-till

Discount Rate	**3.50%**	
Cropland Rental Rate - not CCRP rental rate	**$90.50**	per acre / year
Annual Cropland Rental Growth Rate	**3.00%**	
Total Annual Costs	**$0.00**	per acre / year
Inflation Rate of Annual Costs	**3.00%**	

Project Length (feet)	**660**
Project Width (feet)	**66**
Acres (length x width/43,560)	**1.00**
Length of analysis (years)	**25**
Cropland Property Tax ($/acre)	**$5.00**
Tame Grass Property Tax ($/acre)	**$5.00**

COSTS

Total one-time	
Total annual	**$0.00**

PAYMENTS RECEIVED

Total one-time	**$0.00**
Total annual	**$0.00**

Net Present Value Table: No-till conversion (per acre)

Year	One Time Costs	Annual Costs	One Time Payments	Annual Payments	Cropland rent: Annual Opportunity Cost
0	$68.80	$0.00	$0.00	$0.00	$0.00
1	$0.00	$0.00	$0.00	$0.00	$0.00
2	$0.00	$0.00	$0.00	$0.00	$0.00
3	$0.00	$0.00	$0.00	$0.00	$0.00
4	$0.00	$0.00	$0.00	$0.00	$0.00
5	$0.00	$0.00	$0.00	$0.00	$0.00
6	$0.00	$0.00	$0.00	$0.00	$0.00
7	$0.00	$0.00	$0.00	$0.00	$0.00
8	$0.00	$0.00	$0.00	$0.00	$0.00
9	$0.00	$0.00	$0.00	$0.00	$0.00
10	$0.00	$92.46	$0.00	$0.00	$0.00
11	$0.00	$0.00	$0.00	$0.00	$0.00
12	$0.00	$0.00	$0.00	$0.00	$0.00
13	$0.00	$0.00	$0.00	$0.00	$0.00
14	$0.00	$0.00	$0.00	$0.00	$0.00
15	$0.00	$0.00	$0.00	$0.00	$0.00
16	$0.00	$0.00	$0.00	$0.00	$0.00
17	$0.00	$0.00	$0.00	$0.00	$0.00
18	$0.00	$0.00	$0.00	$0.00	$0.00
19	$0.00	$0.00	$0.00	$0.00	$0.00
20	$0.00	$124.26	$0.00	$0.00	$0.00

21	$0.00	$0.00	$0.00	$0.00	$0.00
22	$0.00	$0.00	$0.00	$0.00	$0.00
23	$0.00	$0.00	$0.00	$0.00	$0.00
24	$0.00	$0.00	$0.00	$0.00	$0.00
25	$0.00	$0.00	$0.00	$0.00	$0.00
26	$0.00	$0.00	$0.00	$0.00	$0.00
27	$0.00	$0.00	$0.00	$0.00	$0.00
28	$0.00	$0.00	$0.00	$0.00	$0.00
29	$0.00	$0.00	$0.00	$0.00	$0.00
30	$0.00	$167.00	$0.00	$0.00	$0.00
31	$0.00	$0.00	$0.00	$0.00	$0.00
32	$0.00	$0.00	$0.00	$0.00	$0.00
33	$0.00	$0.00	$0.00	$0.00	$0.00
34	$0.00	$0.00	$0.00	$0.00	$0.00
35	$0.00	$0.00	$0.00	$0.00	$0.00
36	$0.00	$0.00	$0.00	$0.00	$0.00
37	$0.00	$0.00	$0.00	$0.00	$0.00
38	$0.00	$0.00	$0.00	$0.00	$0.00
39	$0.00	$0.00	$0.00	$0.00	$0.00
40	$0.00	$224.43	$0.00	$0.00	$0.00
41	$0.00	$0.00	$0.00	$0.00	$0.00
42	$0.00	$0.00	$0.00	$0.00	$0.00
43	$0.00	$0.00	$0.00	$0.00	$0.00
44	$0.00	$0.00	$0.00	$0.00	$0.00
45	$0.00	$0.00	$0.00	$0.00	$0.00
46	$0.00	$0.00	$0.00	$0.00	$0.00
47	$0.00	$0.00	$0.00	$0.00	$0.00
48	$0.00	$0.00	$0.00	$0.00	$0.00
49	$0.00	$0.00	$0.00	$0.00	$0.00
50	$0.00	$301.61	$0.00	$0.00	$0.00

Sum totals	$68.80	$1,694.52	$0.00	$0.00	$0.00
NPV	$68.80	$566.62	$0.00	$0.00	$0.00
Net Present Value		**$635.42**			
Annualized Value		**$28.32**			

Capital costs to convert to no-till based on 2014 custom rates for state of Kansas, assuming intensive crop rotation (typical of no-till operations in south central Kansas to maximize profitability and reduce erosion through more continuous crop growth). Custom hire rates to plant wheat ($18.05 per acre) and milo ($18.33 per acre) and drill soybeans ($17.70 per acre) with an additional herbicide application ($14.72 per acre) yield total no-till cost of $68.80 per acre. Typically, a threshold acreage (~400 acres) is enrolled such that the payment can be applied to purchase needed no-till equipment rather than continuing to hire custom no-till operations annually.

Maintenance costs presented above assume new acreage is enrolled in no-till every 10-years to sustain the supply of sediment credits generated per acre no-till to account for unforeseen reversal in tillage methods. In practice, once a landowner opts to enroll in no-till they tend to remain in no-till, particularly if they have purchased necessary equipment. However, this assumption was made to build in additional certainty of continued sediment credit supply for the purpose of developing an appropriate sediment credit payment rate (Section 3.2.4) and sustaining program funding (Section 3.3).

Sediment load reductions assumed for no-till are 3.5 tons/acre/yr, reflecting a 70% sediment retention efficiency over conventional tillage practices. Given this efficiency, the sediment removal cost of no-till is **$8.99 per ton per acre per year.**

Appendix C

Examples of program structures considered and/or adopted by other cities and states with offsite stormwater management programs.

Program Element	Lenexa, KS	Washington, DC[a]	St. Paul, MN[a]	Fredericksburg, VA[a]	North Carolina[a]	Chesapeake Bay, MD[a]	Maine[a]	Charlotte, NC[b]
Program currency	Runoff detention	Runoff Volume	Runoff Volume	Runoff volume	Phosphorus (P), Nitrogen (N)	Phosphorus	Phosphorus	Runoff volume
Eligibility	Not specified	Developments unable to meet onsite minimum retention	Developments unable to meet onsite minimum retention	Open to any development not meeting 1-in volume offset	Developments unable to reduce nitrogen export to predevelopment	Limited to "Critical Areas" within watershed	Limited to projects in selected lake watersheds	Re-development projects
Minimum onsite control measures	Not specified	Must have approved stormwater management program (SWMP) in place	Onsite rate control 2-, 10-, and 100-year storms	Not provided	Not specified, but minimum N and P removal standards are must be met	Must demonstrate onsite volume reductions infeasible	60% onsite P reduction	Not specified
Payment rate ($/impervious ac)[d]	$14,300	Not yet determined	$40,000	Not yet determined	$362 for P[c] $252-$462 for N	$87,750	$67,000	$60k city core; $90k suburbs
Credit ratio	None specified	1:1	1:1 to 1.3:1	1.5:1 new development; 1.25:1 redevelopment	None specified	None specified	None specified	None specified
Spatial bounds	All regional retention projects constructed w/in Lenexa	Within DC district (62 mi^2)	Same subwatershed as project site, preferable within same local jurisdiction	Within same watershed	Same 8-digit hydrologic unit code (HUC), ~ 15-65 mi^2	Same 12-digit HUC watershed, ~ 15-65 mi^2	Same watershed as impacted lake	With City on city-controlled lands or private easements
Program administration	City collects funds (user fees, tax, stormwater utility), identifies offsite BMP locations, and implements and maintains	Under development	District administers credits and keeps record of used and available credits; Onsite and offsite parties arrange transaction and provide District with certification	Under development	Administered by North Carolina Ecosystem Enhancement Program, which implements BMPs through mitigation bank or design/build by private entity	Local jurisdiction responsible for documenting why onsite compliance not feasible and tracking and reporting offset program performance.	Administered by Stormwater Administers who track receipts and offsite payments, annual reports of BMPs implemented, and program expenditures.	Administered by City of Charlotte, which acts to aggregate in-lieu payments from developer and implement BMPs

[a]As summarized by the Center for Watershed Protection, 2012

[b]As reported by Valderrama et al., 2013

[c]Payment rate given per pound N ($12-22) or P ($134 per pound) and were converted to $/impervious acre by assuming annual N and P load of 21 and 2.7 pounds, respectively, per acre impervious surface.

[d]With the exception of the Nuese River Watershed program, all program costs are based on cost offsite BMPs implemented within urban area

Appendix D

Offsite BMP Program Costs, estimated by Program Year

Table D.1: Program costs based on no-till, 50% of acres replaced every 5 years

Table D.2: Program costs based on no-till, 100% of acres replaced every 5 years

Table D.3: Program costs based on streambank stabilization

Description of Table Headings

A. *Year:* Corresponds to the year of the program. For the purposes of estimating total programmatic costs, a program duration of 50 years was assumed.
B. *Annual new/redevelopment (ac):* Acreage of new and redevelopment projects within the City of Wichita that participate in the program. For the purposes of estimating total programmatic costs, a development rate of 600 acres per year was assumed. Given the scaling of program costs to sediment credits needed, costs per acre are relatively similar regardless of the total number assumed.
C. *Cum. (Cumulative) Onsite sediment credit demand (tons):* Corresponds to the estimated sediment load generated per acre new or redevelopment (0.32 tons per acre developed, or about 0.5 tons per impervious acre), expressed as cumulative tonnage for each year of the program. As summarized in Table 5, this sediment load represents a 50-50 mixture of commercial and residential land uses, and assumes a sediment credit ratio of 2:1 (i.e., 2 tons of sediment must be retained offsite to offset 1 ton of sediment generated onsite).
D. *Cum. (Cumulative) Offsite sediment credit supply (tons):* Corresponds to the tonnage of sediment retained through offsite BMPs, as based on the cumulative area of offsite BMPs implemented. For no-till (Tables D.1 and D.2), a sediment retention rate of 3.2 tons per acre per year was assumed. For streambank stabilization (Table D.3), a sediment retention rate of 590 tons per acre stabilized per year (or 590 tons per 347 linear feet stabilized per year) was assumed.
E. *Offsite BMP Implemented:* Refers to the area of cropland converted to no-till (Table D.1 and D.2) or length of streambank stabilized (Table D.3) as needed to provide the supply offsite sediment reduction credits in column D.
F. *Cumulative offsite BMP implemented:* Calculates the cumulative area of no-till (Table D.1 and D.2) or streambank length stabilized (Table D.3) by program year.
G. *Offsite BMP Capital Costs:* Accounts for the cost to construct the area of offsite BMPs from column E. For BMPs implemented after year 0 of the program, an annual inflation factor of 2.7% is applied to construction costs.
H. *Offsite BMP maintenance and replacement costs in time*: Costs in time for all maintenance and/or replacement costs incurred over the lifetime of BMPs implemented in the corresponding program year (i.e., from Column E.). An annual inflation factor of 3% is assumed for maintenance costs.
I. *Admin costs*. Administrative costs in each program year, assumed equal to 30% of total capital and recurring costs.
J. *Total program costs*. The sum of BMP capital, maintenance, and administrative costs over the life of the program, expressed on a cumulative basis.

Table D.1. Example timeline and funding requirements for offsite BMP program based on the cost to meet onsite sediment demand through converting conventionally tilled cropland to no-till. To fulfill permanence requirements, assumed 50% of no-till acres must be replaced every 5-years. A 3% annual inflation rate is assumed.									
A. Year	**B. Annual new and re-develop-ment (ac)**	**C.** Cum. onsite sediment credit demand (tons)	**D.** Cum. offsite sediment credit supply (tons)	**E.** Acreage no-till implemented	**F.** Cum. Offsite BMP implemented	**G.** Offsite BMP capital costs	**H.** Offsite BMP replacement costs, in time	**I.** Admin costs	**J.** Total program costs, cum
0	0	0	3840	1200	1200	$82,560	$-	$8,916.48	$91,476
1	600	384	3840	0	1200	$-	$-	$9,183.97	$100,660
2	600	768	3840	0	1200	$-	$-	$9,459.49	$110,120
3	600	1152	3840	0	1200	$-	$-	$9,743.28	$119,863
4	600	1536	3840	0	1200	$-	$-	$10,035.58	$129,899
5	600	1920	3840	0	1200	$-	$47,854.83	$10,336.64	$188,090
6	600	2304	3840	0	1200	$-	$-	$10,646.74	$198,737
7	600	2688	3840	0	1200	$-	$-	$10,966.15	$209,703
8	600	3072	3840	0	1200	$-	$-	$11,295.13	$220,998
9	600	3456	3840	0	1200	$-	$-	$11,633.98	$232,632
10	600	3840	7680	1200	2400	$-	$55,476.87	$11,983.00	$300,092
11	600	4224	7680	0	2400	$114,282	$-	$12,342.49	$426,717
12	600	4608	7680	0	2400	$-	$-	$12,712.77	$439,430
13	600	4992	7680	0	2400	$-	$-	$13,094.15	$452,524
14	600	5376	7680	0	2400	$-	$-	$13,486.98	$466,011
15	600	5760	7680	0	2400	$-	$64,312.89	$13,891.59	$544,215
16	600	6144	7680	0	2400	$-	$66,242.28	$14,308.33	$624,766
17	600	6528	7680	0	2400	$-	$-	$14,737.58	$639,504
18	600	6912	7680	0	2400	$-	$-	$15,179.71	$654,683
19	600	7296	11520	1200	3600	$-	$-	$15,635.10	$670,318
20	600	7680	11520	0	3600	$-	$74,556.27	$16,104.15	$760,979
21	600	8064	11520	0	3600	$153,586	$76,792.96	$16,587.28	$1,007,945
22	600	8448	11520	0	3600	$-	$-	$17,084.90	$1,025,030
23	600	8832	11520	0	3600	$-	$-	$17,597.44	$1,042,627
24	600	9216	11520	0	3600	$-	$-	$18,125.37	$1,060,753
25	600	9600	11520	0	3600	$-	$86,431.15	$18,669.13	$1,165,853

26	600	9984	11520	0	3600	$-	$178,048.18	$19,229.20	$1,363,130
27	600	10368	11520	0	3600	$-	$-	$19,806.08	$1,382,936
28	600	10752	15360	1200	4800	$-	$-	$20,400.26	$1,403,337
29	600	11136	15360	0	4800	$-	$-	$21,012.27	$1,424,349
30	600	11520	15360	0	4800	$-	$100,197.39	$21,642.64	$1,546,189
31	600	11904	15360	0	4800	$206,407	$206,406.63	$22,291.92	$1,981,294
32	600	12288	15360	0	4800	$-	$-	$22,960.67	$2,004,255
33	600	12672	15360	0	4800	$-	$-	$23,649.49	$2,027,904
34	600	13056	15360	0	4800	$-	$-	$24,358.98	$2,052,263
35	600	13440	15360	0	4800	$-	$116,156.24	$25,089.75	$2,193,509
36	600	13824	15360	0	4800	$-	$358,922.79	$25,842.44	$2,578,275
37	600	14208	19200	1200	6000	$-	$-	$26,617.71	$2,604,892
38	600	14592	19200	0	6000	$-	$-	$27,416.25	$2,632,308
39	600	14976	19200	0	6000	$-	$-	$28,238.73	$2,660,547
40	600	15360	19200	0	6000	$-	$134,656.92	$29,085.89	$2,824,290
41	600	15744	19200	0	6000	$277,393	$416,089.88	$29,958.47	$3,547,732
42	600	16128	19200	0	6000	$-	$-	$30,857.23	$3,578,589
43	600	16512	19200	0	6000	$-	$-	$31,782.94	$3,610,372
44	600	16896	19200	0	6000	$-	$-	$32,736.43	$3,643,108
45	600	17280	19200	0	6000	$-	$156,104.28	$33,718.52	$3,832,931
46	600	17664	23040	1200	7200	$-	$643,149.62	$34,730.08	$4,510,811
47	600	18048	23040	0	7200	$-	$-	$35,771.98	$4,546,583
48	600	18432	23040	0	7200	$-	$-	$36,845.14	$4,583,428
49	600	18816	23040	0	7200	$-	$-	$37,950.50	$4,621,378
50	600	19200	23040	0	7200	$-	$180,967.64	$39,089.01	$4,841,435

Total program capital + maintenance costs (no admin)	**$3,796,594**
Administrative costs at 30% of total program costs:	**$1,044,840**
Total program costs, capital + maintenance + admin	**$4,841,435**

Table D.2. Example timeline and funding requirements for offsite BMP program based on the cost to meet onsite sediment demand through converting conventionally

tilled cropland to no-till. To fulfill permanence requirements, assumed 100% of no-till acres must be replaced every 5-years. A 3% annual inflation rate is assumed.									
A. Year	**B. Annual new and re-develop-ment (ac)**	**C.** Cum. onsite sediment credit demand (tons)	**D.** Cum. offsite sediment credit supply (tons)	**E.** Acreage no-till implemented	**F.** Cum. Offsite BMP implemented	**G.** Offsite BMP capital costs	**H.** Offsite BMP replacement costs, in time	**I.** Admin costs	**J.** Total program costs, cum
0	0	0	3840	1200	1200	$82,560	$-	$15,356.16	$97,916
1	600	384	3840	0	1200	$-	$-	$15,816.84	$113,733
2	600	768	3840	0	1200	$-	$-	$16,291.35	$130,024
3	600	1152	3840	0	1200	$-	$-	$16,780.09	$146,804
4	600	1536	3840	0	1200	$-	$-	$17,283.49	$164,088
5	600	1920	3840	0	1200	$-	$95,709.67	$17,802.00	$277,600
6	600	2304	3840	0	1200	$-	$-	$18,336.06	$295,936
7	600	2688	3840	0	1200	$-	$-	$18,886.14	$314,822
8	600	3072	3840	0	1200	$-	$-	$19,452.72	$334,275
9	600	3456	3840	0	1200	$-	$-	$20,036.31	$354,311
10	600	3840	7680	1200	2400	$-	$110,953.74	$20,637.39	$485,902
11	600	4224	7680	0	2400	$114,282	$-	$21,256.52	$621,441
12	600	4608	7680	0	2400	$-	$-	$21,894.21	$643,335
13	600	4992	7680	0	2400	$-	$-	$22,551.04	$665,886
14	600	5376	7680	0	2400	$-	$-	$23,227.57	$689,114
15	600	5760	7680	0	2400	$-	$128,625.79	$23,924.40	$841,664
16	600	6144	7680	0	2400	$-	$132,484.56	$24,642.13	$998,791
17	600	6528	7680	0	2400	$-	$-	$25,381.39	$1,024,172
18	600	6912	7680	0	2400	$-	$-	$26,142.83	$1,050,315
19	600	7296	11520	1200	3600	$-	$-	$26,927.12	$1,077,242
20	600	7680	11520	0	3600	$-	$149,112.54	$27,734.93	$1,254,089
21	600	8064	11520	0	3600	$153,586	$153,585.92	$28,566.98	$1,589,828
22	600	8448	11520	0	3600	$-	$-	$29,423.99	$1,619,252
23	600	8832	11520	0	3600	$-	$-	$30,306.71	$1,649,559
24	600	9216	11520	0	3600	$-	$-	$31,215.91	$1,680,775
25	600	9600	11520	0	3600	$-	$172,862.31	$32,152.39	$1,885,789
26	600	9984	11520	0	3600	$-	$356,096.35	$33,116.96	$2,275,003
27	600	10368	11520	0	3600	$-	$-	$34,110.47	$2,309,113

28	600	10752	15360	1200	4800	$-	$-	$35,133.78	$2,344,247
29	600	11136	15360	0	4800	$-	$-	$36,187.80	$2,380,435
30	600	11520	15360	0	4800	$-	$200,394.79	$37,273.43	$2,618,103
31	600	11904	15360	0	4800	$206,407	$412,813.27	$38,391.63	$3,275,715
32	600	12288	15360	0	4800	$-	$-	$39,543.38	$3,315,258
33	600	12672	15360	0	4800	$-	$-	$40,729.68	$3,355,988
34	600	13056	15360	0	4800	$-	$-	$41,951.57	$3,397,939
35	600	13440	15360	0	4800	$-	$232,312.48	$43,210.12	$3,673,462
36	600	13824	15360	0	4800	$-	$717,845.58	$44,506.43	$4,435,814
37	600	14208	19200	1200	6000	$-	$-	$45,841.62	$4,481,655
38	600	14592	19200	0	6000	$-	$-	$47,216.87	$4,528,872
39	600	14976	19200	0	6000	$-	$-	$48,633.37	$4,577,506
40	600	15360	19200	0	6000	$-	$269,313.84	$50,092.37	$4,896,912
41	600	15744	19200	0	6000	$277,393	$832,179.77	$51,595.15	$6,058,080
42	600	16128	19200	0	6000	$-	$-	$53,143.00	$6,111,223
43	600	16512	19200	0	6000	$-	$-	$54,737.29	$6,165,960
44	600	16896	19200	0	6000	$-	$-	$56,379.41	$6,222,340
45	600	17280	19200	0	6000	$-	$312,208.55	$58,070.79	$6,592,619
46	600	17664	23040	1200	7200	$-	$1,286,299.24	$59,812.91	$7,938,731
47	600	18048	23040	0	7200	$-	$-	$61,607.30	$8,000,339
48	600	18432	23040	0	7200	$-	$-	$63,455.52	$8,063,794
49	600	18816	23040	0	7200	$-	$-	$65,359.19	$8,129,153
50	600	19200	23040	0	7200	$-	$361,935.28	$67,319.96	$8,558,409

Total program capital + maintenance costs (no admin)	**$6,758,961**
Administrative costs at 30% of total program costs:	**$1,799,446**
Total program costs, capital + maintenance + admin	**$8,558,409**

Table D.3. Example timeline and funding requirements for offsite BMP program based on the cost to meet onsite sediment demand through streambank stabilization projects. A 3% annual inflation rate is assumed.

A. Year	B. Annual new and re-development (ac)	C. Cum. onsite sediment credit demand (tons)	D. Cum. offsite sediment credit supply (tons)	E. Offsite BMP implemented		F. Cum. Offsite BMP implemented		G. Offsite BMP capital costs	H. NPV of offsite BMP recurring costs at program year implemented	I. Admin costs	J. Total program costs, cum
				Streambank stabilized (linear ft)	Riparian area stabilized (ac)	Streambank stabilized (linear ft)	Riparian area stabilized(ac)				
0	0	NA	NA	2260	6.5	2260	6.5	$240,764		$14,681	$255,444
1	600	384	3842	0	0.0	2260	6.5	$0	$22,334	$14,681	$292,459
2	600	768	3842	0	0.0	2260	6.5	$0	$0	$14,681	$307,140
3	600	1152	3842	0	0.0	2260	6.5	$0	$0	$14,681	$321,820
4	600	1536	3842	0	0.0	2260	6.5	$0	$0	$14,681	$336,501
5	600	1920	3842	0	0.0	2260	6.5	$0	$0	$14,681	$351,182
6	600	2304	3842	1120	3.2	3380	6.5	$139,998	$0	$14,681	$505,861
7	600	2688	5746	0	0.0	3380	9.7	$0	$13,433	$14,681	$533,974
8	600	3072	5746	0	0.0	3380	9.7	$0	$0	$14,681	$548,655
9	600	3456	5746	0	0.0	3380	9.7	$0	$0	$14,681	$563,336
10	600	3840	5746	1500	4.3	4880	14.0	$208,583	$0	$14,681	$786,599
11	600	4224	8296	0	0.0	4880	14.0	$0	$19,734	$14,681	$821,014
12	600	4608	8296	0	0.0	4880	14.0	$0	$0	$14,681	$835,695
13	600	4992	8296	0	0.0	4880	14.0	$0	$0	$14,681	$850,376
14	600	5376	8296	0	0.0	4880	14.0	$0	$0	$14,681	$865,056
15	600	5760	8296	0	0.0	4880	14.0	$0	$0	$14,681	$879,737
16	600	6144	8296	720	2.1	5600	14.1	$117,474	$0	$14,681	$1,011,892
17	600	6528	9520	0	0.0	5600	16.1	$0	$11,493	$14,681	$1,038,066
18	600	6912	9520	0	0.0	5600	16.1	$0	$0	$14,681	$1,052,746
19	600	7296	9520	0	0.0	5600	16.1	$0	$0	$14,681	$1,067,427
20	600	7680	9520	0	0.0	5600	16.1	$0	$0	$14,681	$1,082,108
21	600	8064	9520	0	0.0	5600	16.1	$0	$0	$14,681	$1,096,789
22	600	8448	9520	1110	3.2	6710	16.1	$212,498	$0	$14,681	$1,323,967
23	600	8832	11407	0	0.0	6710	19.3	$0	$20,752	$14,681	$1,359,400
24	600	9216	11407	0	0.0	6710	19.3	$0	$0	$14,681	$1,374,081
25	600	9600	11407	0	0.0	6710	19.3	$0	$0	$14,681	$1,388,762
26	600	9984	11407	0	0.0	6710	19.3	$0	$0	$14,681	$1,403,442
27	600	10368	11407	1110	3.2	7820	19.3	$242,777	$0	$14,681	$1,660,900
28	600	10752	13294	0	0.0	7820	22.5	$0	$24,526	$14,681	$1,700,107

29	600	11136	13294	0	0.0	7820	22.5	$0	$0	$14,681	$1,714,787
30	600	11520	13294	0	0.0	7820	22.5	$0	$0	$14,681	$1,729,468
31	600	11904	13294	1110	3.2	8930	22.5	$270,078	$0	$14,681	$2,014,227
32	600	12288	15181	0	0.0	8930	25.7	$0	$27,245	$14,681	$2,056,152
33	600	12672	15181	0	0.0	8930	25.7	$0	$0	$14,681	$2,070,833
34	600	13056	15181	0	0.0	8930	25.7	$0	$0	$14,681	$2,085,513
35	600	13440	15181	0	0.0	8930	25.7	$0	$0	$14,681	$2,100,194
36	600	13824	15181	1110	3.2	10040	25.7	$308,561	$0	$14,681	$2,423,436
37	600	14208	17068	0	0.0	10040	28.9	$0	$32,245	$14,681	$2,470,362
38	600	14592	17068	0	0.0	10040	28.9	$0	$0	$14,681	$2,485,043
39	600	14976	17068	0	0.0	10040	28.9	$0	$0	$14,681	$2,499,723
40	600	15360	17068	0	0.0	10040	28.9	$0	$0	$14,681	$2,514,404
41	600	15744	17068	1110	3.2	11150	28.9	$352,528	$0	$14,681	$2,881,613
42	600	16128	18955	0	0.0	11150	32.1	$0	$36,880	$14,681	$2,933,174
43	600	16512	18955	0	0.0	11150	32.1	$0	$0	$14,681	$2,947,854
44	600	16896	18955	0	0.0	11150	32.1	$0	$0	$14,681	$2,962,535
45	600	17280	18955	1110	3.2	12260	32.1	$392,171	$0	$14,681	$3,369,387
46	600	17664	20842	0	0.0	12260	35.3	$0	$42,409	$14,681	$3,426,476
47	600	18048	20842	0	0.0	12260	35.3	$0	$0	$14,681	$3,441,157
48	600	18432	20842	0	0.0	12260	35.3	$0	$0	$14,681	$3,455,838
49	600	18816	20842	0	0.0	12260	35.3	$0	$0	$14,681	$3,470,518
50	600	19200	20842	0	0.0	12260	35.3	$0	$0	$14,681	$3,485,199

Total program capital + maintenance costs (no admin)	$2,495,720
Administrative costs at 30% of total program costs:	$748,716
Total program costs, capital + maintenance + admin	$3,485,199

Appendix E

Little Ark WRAPs watershed field sign up sheet

The Little Arkansas WRAPS program currently uses a field sign up approach to enroll landowners in sediment reducing practices. In the current program, sediment is valued at a rate of $50 per acre. Each water quality BMP is weighted according to an accepted percent sediment removal efficiency, the value of which is multiplied by the $50 per ton sediment rate to determine the payment the landowner will receive. For example, if a producer signed this contract to convert 500 acres of conventionally tilled cropland in no-till, the producer would receive a total payment of $18,750 ($50/acre x 500 acres x 75%). This sum would be paid out over a five-year period, with each payment made following a visit by the WRAPS-affiliated BMP agent.

Little Ark WRAPS Watershed Field Sign Up Sheet

KSTATE Kansas State University Research and Extension

SCC KANSAS

Sediment Reduction Project

SD 01

	Best Management Practices	Erosion Reduction Efficiency (%)
___	Establish riparian vegetative buffer (check width) ___ less than 30' wide ___ 30' to 60' wide ___ greater than 60' wide	 .25 .40 .50
___	No-till	.75
___	Crop rotations	.25
___	Conservation till (≥30% residue following planting)	.30
___	Farm on the contour	.35
___	Establish new terraces	.30
___	Establish contour grass strips	.50
___	Establish grassed waterways	.30
___	Establish permanent grass	.95
___	Other	
	Total Erosion Reduction (TER) (accumulative effect of BMP's)	

Field Legal Description: ____

Land Operator/Manager _____________________________________

Address and Telephone Number ____

____

Total Payment = ERE% x acres _________ x $50 **$** ________________
Payments will be split over 5 years. Payments will be made after visit with BMP agent.
I agree to implement this practice(s) and maintain it for 5 years.

Land Manager/Operator ____ Date: ________________

BMP Agent ____